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TECHNICAL CONTRIBUTIONS

The Journal of the Australian Institute of Agricultural Science will consider for publication original papers of three types: Reviews and Articles, Technical Notes and Technical Articles. Information on the general form and size of these types of papers was set out in Volume 21, page 2 (March 1955). The information on form and size still holds but we have been forced to make some changes in our policy on technical contributions.

There are no restrictions on our intake of Reviews and Technical Notes but over the past few issues we have found it necessary to limit the number of Technical Articles. It seems likely that this policy will continue for some time.

TECHNICAL ARTICLES

We will still consider Technical Articles reporting in detail the completed results of research projects, but authors submitting such papers must recognise that:

1. These papers have the lowest priority. They can only be published if, and when, there is a shortage of contributions of other types. Reviews and Articles and Technical Notes will be given preference.

2. Whenever it is at all possible we will request that Technical Articles be cut to Technical Note form and length.

3. There is an absolute upper limit of eight Journal pages (equivalent to 4500 words) including figures and tables.

TECHNICAL NOTES

We welcome Technical Notes on a wide range of topics. As we see it a Technical Note should consist of a set of results, presented in either table or graph form together with the minimum comment necessary to explain the results. The Note needs neither summary nor conclusion. The basic pattern is a brief introduction to set the problem in its context, a statement of methods, the actual results, and brief comment on the implication of the more important results. Such a Note cannot be, and is not intended to be, a full report of work completed. We believe that its function lies in bringing work to the attention of readers who can then communicate with the author for further details.

Technical Notes may deal with completed projects, partial results from long term work, side results of other projects, or they may describe new techniques or pieces of equipment.

HEAT CONDUCTION AND TEMPERATURE PROFILES IN AIR AND SOIL

C. H. B. PRIESTLEY

1. Introduction

When heat is supplied to or withdrawn from the interface between the atmosphere and its underlying medium, the temperature behaviour in the layers close to the surface is largely controlled by conduction, or a process very similar thereto. The object here is to discuss the most significant features of this response, and in particular to illustrate how the temperature response of both media is sensitive to the type and condition of the underlying one (soil or water). We shall not attempt to review or even to summarize, as such, the large amount of factual information about the temperature behaviour which has been collected, e.g. by Geiger (translated 1950). Such information can cover only a relatively small sample of the infinite variety of conditions actually existing. It is hoped that the present more basic discussion of the mechanisms involved will provide the agricultural scientist with a better understanding with which to approach the practical problems and interpret the data, both that already published and further variations which may be encountered in the field.

2. Characteristics of Conduction

Ignoring the irregularities associated with eddying motions of the air, which will be the subject of discussion in a later Section, the gradients of temperature existing in air and soil are much greater in a vertical than in a horizontal direction. Thus even in the most strongly contrasting conditions the horizontal variations are to be measured in degrees per mile whereas close to the surface, both above and below, the vertical differences are some degrees per foot. For practical purposes, therefore, we may consider the process of conduction as operating in one direction only, i.e. the vertical. The law of conduction then states that the rate of (vertical) heat flow per unit (horizontal) area will be equal to k times the (vertical) temperature gradient, or change of temperature per unit distance. k is a property of the medium in question and is called the *thermal conductivity*.

It will help to clarify some of the characteristics of conduction if we first consider the process as operating only in

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Dr. C. H. B. Priestley is Chief, Division of Meteorological Physics, C.S.I.R.O. *This paper records a lecture in a series on Micrometeorology in Agriculture that was given by officers of the Division of Meteorological Physics in the school of Agriculture, University of Melbourne, during* 1958. *Papers already published in this Journal—Frost Prevention* (*Angus* 1956) *and Evaporation Measurement* (*McIlroy* 1957)*—provided much of the material of other lectures.*

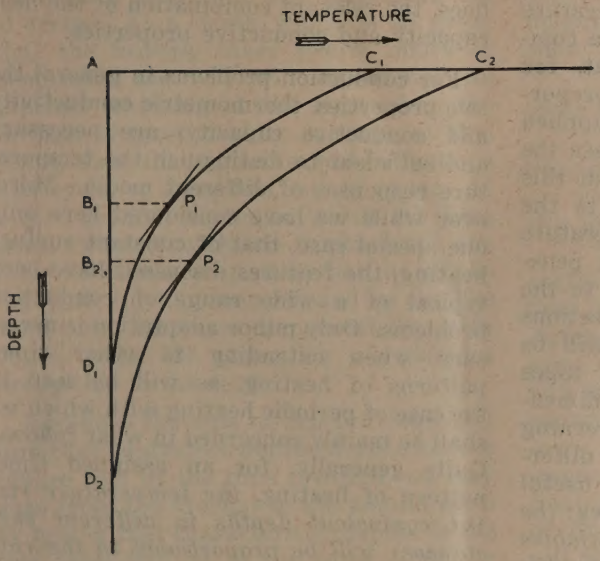

Figure 1—Successive temperature profiles in soil for case of constant surface heating.

the one medium, i.e. soil. We shall suppose the soil to be initially at a uniform temperature T_i and, from a given moment (zero) of time onwards, heat to be supplied to the surface at a known constant rate. The temperature change will be in proportion to the heat supply. In Figure 1 we represent the state of affairs after intervals t_1, t_2 by *temperature profiles* such as C_1 P_1 D_1, C_2 P_2 D_2 where the lengths AC_1, B_1 P_1, etc., are drawn proportional to the temperature increase at A, B, etc., at the time in question, depth being represented along the vertical axis ABD. Ideally the profiles do not intersect the vertical axis but it is of practical convenience to define the total depth penetrated, AD, by the level at which the rise in temperature is some conventional small fraction of its value at the surface. At intermediate points such as B_1 the temperature gradient is represented by the slope, to the vertical, of the profile at P_1, and this slope is therefore proportional to the downward heat flux at B_1 at time t_1. At a later time t_2, the same heat flux will be experienced at a greater depth B_2, determined by the parallelism of the tangents at P_1 and P_2.

Using H to denote vertical heat flux downwards and $\delta T/\delta z$ the increase of temperature T with depth z at any time, the law defined above is written

$$H = -k \frac{\delta T}{\delta z} \qquad 1$$

Now if we apply a given amount of heat to the same volume of different substances, the temperature changes will be in inverse proportion to their heat capacities, or to ρ times c where ρ is density and c is specific heat. In all problems where the interest centres in temperature response, and thus in $H/\rho c$ rather than H itself, it is more convenient to use equation 1 in the form

$$\frac{H}{\rho c} = -\frac{k}{\rho c} \frac{\delta T}{\delta z} = -\kappa \frac{\delta T}{\delta z} \qquad 2$$

where the property κ is known as the *thermometric conductivity* or *heat diffusivity*. Henceforward we shall deal exclusively with κ in preference to k. It is readily seen that κ has the dimensions of the square of a length divided by time.

It is fairly clear intuitively, and can be proved in a full mathematical treatment

of the problem*, that the temperature profiles at successive times retain a common similarity of form and that, for example, AC and AD increase in proportion to each other. The total heat supplied is given by the area enclosed between the profile and the vertical axis, so that this area will increase in proportion to the time. It follows that both the temperature rise at the surface and the depth penetrated will increase in proportion to the square root of the time. Given fractions of the surface temperature rise will be experienced at depths where z^2/t takes given values. This has the same dimensions as κ, which is the quantity governing differences of response as between different substances, and so a very useful general law can be framed as follows: *the dimensionless combination of variables represented by $z^2/\kappa t$ will characterize the degree of penetration whatever the depth, time and substance.* As a special case, for heating of different substances after a given time the depth penetrated will be proportional to $\sqrt{\kappa}$. We may accordingly refer to 'equivalent depths' in two different substances, implying values of z which give the same value of $z^2/\kappa t$ in the two instances.

Equivalent depths refer to the depths at which a given fraction of the surface temperature change is experienced. To compare the actual magnitudes of the changes as between different substances we note that the heat capacity per unit volume is proportional to ρc, the penetration to $\sqrt{\kappa}$, so that the total heat capacity taking part in the process will vary as $\rho c\sqrt{\kappa}$. The temperature change is therefore inversely proportional to $\rho c\sqrt{\kappa}$. This is a combination of variables which constantly recurs in conduction problems. It represents a property of the medium to which no accepted name has yet been given and will here be referred to as the *conductive capacity* representing, as it does, the relevant combination of the heat capacity and conductive properties.

For conduction problems in general the two properties, thermometric conductivity and conductive capacity, are necessary and sufficient to distinguish the temperature responses of different media. Moreover while we have considered here only one special case, that of constant surface heating, the features discussed have been typical of a wide range of conduction problems. Only minor adaptation is necessary when extending to other time-patterns of heating, as will be seen in the case of periodic heating with which we shall be mainly concerned in what follows. Quite generally, for an assigned time-pattern of heating, *the temperature rise (at equivalent depths in different substances) will be proportional to the rate of heat supply and inversely to the conductive capacity.* Again for an assigned time-pattern of heating, the italicised rule given earlier retains generality and continues to serve as the means of identifying the equivalent depths of different substances. The relation between fraction of surface change and $z^2/\kappa t$ however is not unique, but will depend on the nature of the pattern.

3. Penetration of a Simple Harmonic Wave

From the foregoing example we may readily proceed to the more practical one in which the surface is subjected to the alternation between heating by solar radiation by day and cooling by outgoing radiation at night. During the daytime the heat will spread downwards, suffering dilution as it goes, so that the amplitude of the temperature cycle will decrease with increasing depth. Moreover since heating at the surface takes time to penetrate, the greatest rate of warming at depth will be experienced progressively later than at the surface. The alternation of heating and cooling at the surface will therefore result in an alternation of the same period of warming and cooling at every depth, but with progressively

*The mathematical background of this and other problems here discussed is given by Carslaw and Jaeger (1947).

diminished amplitude and increasing lag in phase. At a depth which is so great that the heating takes twelve hours to penetrate, the soil will experience its greatest warming at the time when the surface is most rapidly cooling; at this depth, then, the oscillation will be just one half cycle, or π radians, out of phase. At a still greater depth, to which the heat takes twenty-four hours to penetrate, the cycle will again be in phase but the amplitude still further reduced, and so on. The amplitude decreases exponentially with depth, while the phase lag increases in proportion to the depth.

Applying the rule of the previous Section that equivalent depths depend on the square root of the time involved, we may pass from the diurnal to the annual cycle by noting that characteristic depths in the two cases will be in the ratio $\sqrt{365}$, or 19.1 approximately. Governed by this interdependence of the depth and time scales the behaviour will be generally similar, and henceforward we shall need to consider the diurnal variation only.

The upper part of Table 1 gives characteristic depths at which amplitude reductions and phase shifts of various magnitudes are experienced in typical soils. The amplitude at any depth z is given by $\exp\left\{\frac{-z}{z_1}\right\}$ times the amplitude at the surface, where z_1 is the depth at which the amplitude is reduced to $\frac{1}{e}$ of the surface value and is shown in the first column of depths in the table. Again we note the applicability of our previous rules, that the depth affected will be proportional to $\sqrt{\kappa}$, the total heat capacity taking part in the process to $\rho c\sqrt{\kappa}$, and the actual temperature response inversely to the latter. A more comprehensive list of the typical values of the constants pertaining to different soil types and conditions is given in the upper part of Table 2.

While the main lessons to be learnt from this paper concern the comparative behaviour of different soils, or different media, it may be helpful at this stage to provide a yardstick for the actual magnitude of the temperature response.

TABLE 1

Depth of penetration of diurnal wave.

κ (cm²/sec).	Type	*Amplitude reduction*			*Phase shift*	
		$\frac{1}{e}$	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{\pi}{2}$	π
1.4×10^{-3}	Dry sand Still water	6 cm	14 cm	28 cm	10 cm	20 cm
4×10^{-3}	Moist soils	10.5 cm	24 cm	48 cm	16.5 cm	33 cm
10^{-2}	Wet sand Ice	16.5 cm	38 cm	76 cm	26 cm	52 cm
100	Stirred water	16.5 m	38 m	76 m	26 m	52 m
10^4	Atmosphere	165 m	380 m	760 m	260 m	520 m

TABLE 2

Physical properties of different media.

	ρc (cal/cm^3 °C)	κ or K (cm^2/sec)	$\rho c\sqrt{\kappa}$ or $\rho c\sqrt{K}$ (cal-cgs units)	Authority
New snow	0.03	0.006	0.002	Geiger (1948)
Old snow	0.22	0.003	0.012	„
Dry sand	0.3	0.0013	0.011	„
Wet sand	0.4	0.01	0.04	„
Sandy clay (15% moisture)	0.59	0.0037	0.036	Lettau (1951)
Concrete	0.54	0.011	0.057	„
Organic soil	0.57	0.005	0.04	Geiger (1948)
Wet marshy soil	0.7	0.003	0.038	„
Granite rock	0.5	0.02	0.07	„
Ice	0.45	0.012	0.05	„
Still water	1.0	0.0015	0.039	Physical tables
Ocean (a)	1	0.1	0.32	Sverdrup *et al.* (1942)
(b)	1	50	7	„
(c)	1	300	17	„
Still air	3×10^{-4}	0.2	1.3×10^{-4}	Physical tables
Atmosphere, stable	3×10^{-4}	10^3	0.01	Various
Atmosphere, unstable	3×10^{-4}	10^5	0.1	„
Atmosphere, stirred by strong winds	3×10^{-4}	10^5	0.1	„

(a) Great stability, moderate currents
(b) Moderately stable, strong currents
(c) Homogeneous, strong currents

To do this we shall suppose the heating of the soil to be a simple harmonic function with an amplitude of 10 milliwatts per cm^2 (8.6 calories per cm^2 per hour) and mean value zero, i.e. the amount withdrawn at night is taken to equal that supplied by day. As will be seen more clearly in Section 6, in nature the heating rate is itself governed by the type and condition of the soil, but with the values assumed above the amplitude of the temperature response at the surface will be 7.0°C for a soil with a conductive capacity 0.04, e.g. wet sand. The maximum and minimum temperatures at the surface will lag $\pi/4$ (3 hours) behind the times of maxima of heating and heat withdrawal rates.

In practice one will encounter the difficulty that the soil type and its moisture condition is not constant with depth. This complication cannot be discussed in detail where we are concerned with principles and overall patterns of behaviour, and we shall here throughout consider the physical properties as invariant with

depth. This will generally represent a fair approximation to the real behaviour provided that the values assumed are averages over the depth taking part in the process.

Of the major implications of Table 1 and Table 2 we note that, although the reversal of phase may occur at quite a small depth, particularly with dry soil, the amplitude at this depth is such a small fraction of the surface value that the reversal may be disregarded for most practical purposes. The conductive capacities of the wet soils are more or less equal and we may expect similar variations of surface temperature, but they are compounded somewhat differently in terms of heat capacity and conductivity so that there would be rather deeper penetration into the wet sand. The more significant differences, however, are those that exist between dry and wet soils. The former will show around four times as large a temperature response to a given heat supply; note here that it is a difference of conductivity rather than heat capacity which dominates the conductive capacity. There will also be important differences according to the degree of compactness of the soil, and this is brought out in Table 2 by a sixfold difference in conductive capacity, and hence in temperature response, as between old and new snow or as between concrete or granite and the natural dry soils. Compaction of soil is thus an excellent means of reducing its temperature by day and increasing it at night, but there are other effects to consider and this question will be taken up more fully in Section 6.

4. The Atmosphere as a Conducting Medium

The vertical transfer of heat in the atmosphere, or in water when this is the underlying medium, differs from that in the soil in that the medium itself is mobile. We cannot consider the transfer of heat without first considering the factors which govern the motion.

The pressure in the atmosphere is hydrostatic, that is to say it is determined by the weight of air above, so that when an element moves upwards it moves into a region of lower pressure. In doing so it expands and cools. The rate at which a rising element will cool, assuming that it gives out or receives no heat from the environment, is known as the *adiabatic lapse rate* and is very closely equal to 1°C per 100 metres.

If the atmosphere were rapidly and completely mixed, an adiabatic lapse rate would result. However during the day, when heated from below, the lower layers take up the heating more strongly and the decrease of temperature with height becomes greater: the lapse rate becomes *superadiabatic*. With cooling from below, the decrease of temperature with height becomes weaker, or *subadiabatic*: when the cooling is sufficiently strong and prolonged, the temperature will increase with height in the surface layers, a condition known as *inversion*.

Typical temperature profiles under conditions of pronounced surface heating and cooling are shown as AC and AD in Figure 2, AB representing the adiabatic condition. Consider an element at the point P in the superadiabatic environment. If this element were to be displaced upwards through some adventitious circumstance it would move along the line PP', parallel to AB. In its displaced position it would find itself warmer and therefore lighter than its environment, and would tend to move further. If it were originally displaced downwards, it would become cooler and denser than its environment, and would again tend to continue its motion. On the other hand an element at Q, anywhere on the curve AD, would after displacement experience a force tending to restore it to its original position. It is clear that a superadiabatic condition will be inclined to promote and magnify the adventitious vertical motions, or vertical *turbulence*, while a subadiabatic or inversion condition will be inclined

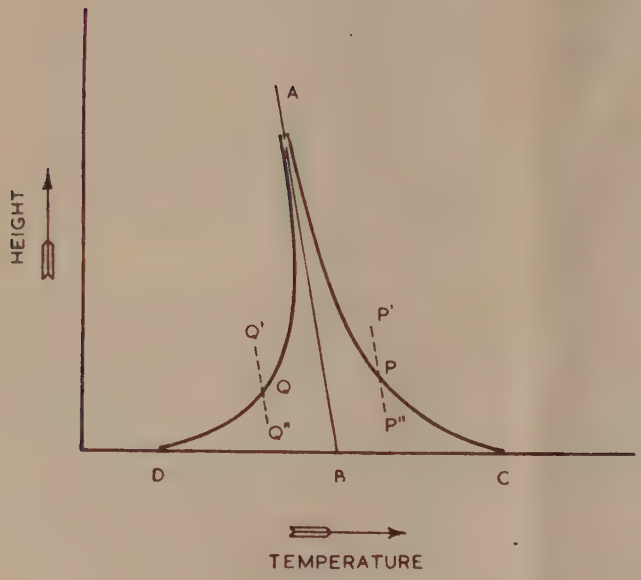

Figure 2—Unstable (superadiabatic, AC) and stable (subadiabatic and inversion, AD) temperature profiles in the atmosphere.

to damp out any turbulence which might otherwise tend to be present. These conditions are therefore frequently referred to respectively as *unstable* and *stable.*

While superadiabatic or unstable conditions will actively generate turbulence, turbulence is present in some degree in nearly all circumstances except those of absolute calm. Since a fluid in contact with a solid must be at rest at the boundary, the presence of any mean horizontal motion, or wind, necessarily implies the existence of wind shear in the lower layers. In general this wind shear is the prime generator of turbulence, and the effects of thermal stratification serve to diminish or enhance the motions so brought about. Other things being equal, the degree of turbulence will also depend on the roughness of the ground but these effects will be much reduced above a few times the height of the roughness elements.

Eddying motions, acting in the presence of a gradient of temperature, will serve to transport heat from the warmer to the colder regions. We shall next consider how to represent this action formally and —because here again the gradients are so much larger in the vertical than in the horizontal direction—shall be concerned only with the vertical component of heat transfer. Let us fix attention on a horizontal plane at an assigned height or reference level and consider an element of air which is momentarily positioned at this level. If ρ denotes the density, w the upwards velocity, and T the temperature of this element, the element will be effecting heat transport at the rate $c_p \rho w T$ per unit area, c_p being the specific heat at constant pressure. Using a bar to denote the average taken over all the elements which are in the reference plane at a given instant, the heat flux or rate of transport per unit area is

$$H = c_p \overline{\rho w T} \qquad 3$$

As in Section 2, a positive sign denotes the direction away from the interface. There can be no depletion of the actual mass of air below the reference level, which is to say that the average value

$\overline{\rho w}$ is quite negligible compared with the individual values ρw, positive or negative, of the turbulent elements. Furthermore $\overline{T}$ is the average temperature at the level in question, and if T' is used to denote departures in excess of this value, so that $T = \overline{T} + T'$, we may write

$$H = c_p \, \overline{\rho w \overline{T}} + c_p \, \overline{\rho w T'}$$

$\overline{T}$ is a constant within the averaging process, and the first of these terms is therefore $\overline{\rho w}\,\overline{T}$, which is zero since $\overline{\rho w}$ is zero. Hence

$$H = c_p \, \overline{\rho w T'}$$

Within the averaging process implied by the bar over the expression on the right, both w and T' are highly variable quantities taking on extreme positive and negative values, whereas ρ varies, as between one element and another, by only a small fraction of its mean value. For our present purpose it is valid to treat ρ as a constant, giving

$$H = c_p \, \rho \, \overline{wT'} \qquad 4$$

We next recognize that the temperature excess or deficit T' is primarily due to the fact that an element has come from a level where the average temperature is different from that of the reference level. Suppose, for the sake of definiteness, the element we are considering has risen from a distance l below: the fact that it may equally have come from above is recognized by allowing l to be either positive or negative. Since $\delta\overline{T}/\delta z$ denotes the increase of temperature with height, z, the element will have started with a temperature deficit $l\delta\overline{T}\delta z$ below that of the reference level: further in rising through the distance l, its temperature will have fallen by $l\Gamma$, where Γ is the adiabatic lapse rate. Therefore

$$T' = -l \left(\frac{\delta\overline{T}}{\delta z} + \Gamma \right)$$

Within the averaging process in equation 4 the quantity $\delta T/\delta z + \Gamma$ is a constant, and this equation now becomes.

$$\frac{H}{\rho c_p} = -\overline{wl} \left(\frac{\delta\overline{T}}{\delta z} + \Gamma \right)$$

The quantity $\overline{wl}$ denotes an average value of the product over all the elements which are found in the reference plane at a given instant of time. Of the individual elements, those that have moved from below will have both w and l positive, those from above will have both w and l negative, so that the product $\overline{wl}$ is necessarily positive. It is a quantity which depends only on the characteristics of the actual pattern of the turbulent motion, i.e. it is composed of motions and displacements and does not include temperature or any other thermal quantity. We write, accordingly

$$\overline{wl} = K$$

where K, the *eddy conductivity*, has the same dimensions as κ, the thermometric conductivity of a solid and plays an analogous role thereto, as is seen more clearly by writing the heat flux equation now as

$$\frac{H}{\rho c_p} = -K \left(\frac{\delta\overline{T}}{\delta z} + \Gamma \right) \qquad 5$$

and comparing with equation 2. The only formal difference is that it is $T + \Gamma z$ rather than T itself which is conserved in the motion, and whose vertical gradient governs the direction and magnitude of the heat flux. In effect the departure of the temperature profile from the adiabatic has replaced the temperature profile itself, while a measure of eddy activity K has replaced a physical property of the same dimensions.

Unlike κ, K is of course not a constant but will be dependent on wind speed and is highly sensitive to the degree of stability imposed by the temperature stratification. It also increases with height

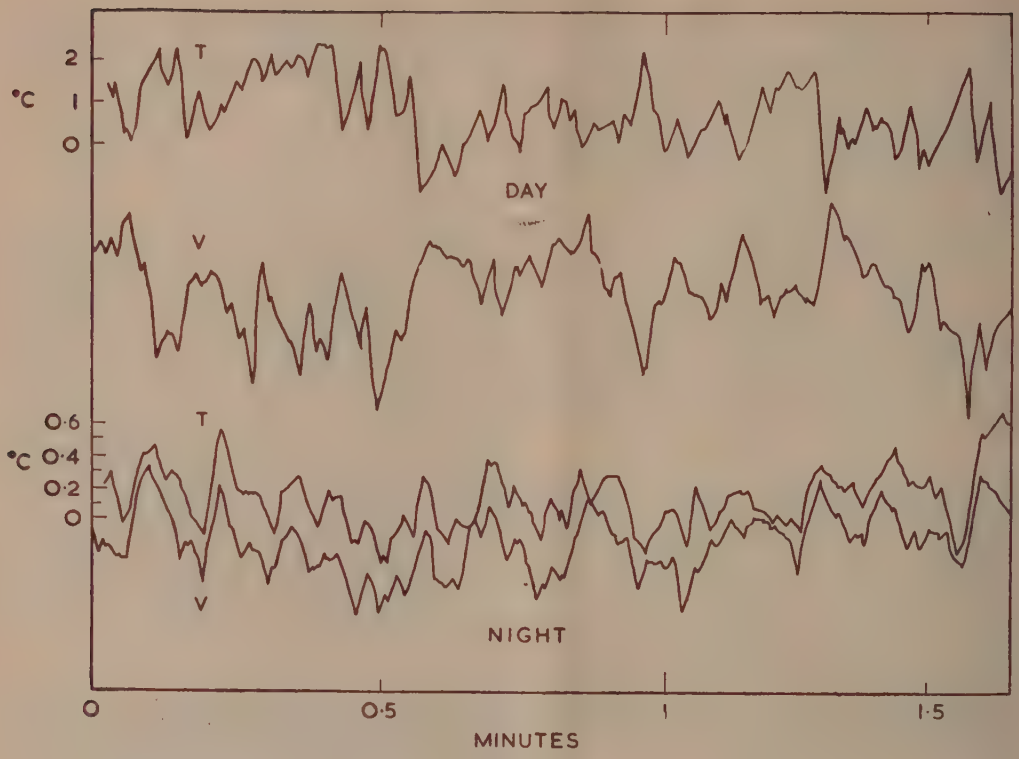

Figure 3—Simultaneous records of T and V at 1.5 metres, wind speed 2.7 to 2.9 metres per second.

above ground through the lowest 100 feet or so of the atmosphere, but we shall not here consider the complications due to this cause and will be content to adopt overall average values through the layers which are most active in the processes under consideration.* Typical values are given in the lower part of Table 2; in using them is must be remembered that they have order-of-magnitude significance only. The values for the (artificial) condition of perfectly still air, when K reverts to the molecular value κ, are also shown for comparison and it is seen that even in the more stable regimes the process of eddy conduction is some three to four orders of magnitude stronger than that of molecular conduction. Apart from this change of magnitude and the, relatively small, correction implied by the Γ term in equation 5, we may carry over to the atmosphere the general properties of conduction processes as discussed for soils in Sections 2 and 3. An example has already been given in the lower part of Table 1. We must, however, bear constantly in mind the very important differences in degree as between the stable and unstable conditions typical of night and day respectively.

We may appropriately conclude this Section with a few examples of fluctuation records obtained in the surface layers of the atmosphere at Edithvale, Victoria.

*This simplification yields generally correct values of heat quantities but does produce amplitude reductions below about a metre and phase distortions for a few metres above the surface. Applications where the errors are important call for a more elaborate treatment (e.g. Lettau 1951).

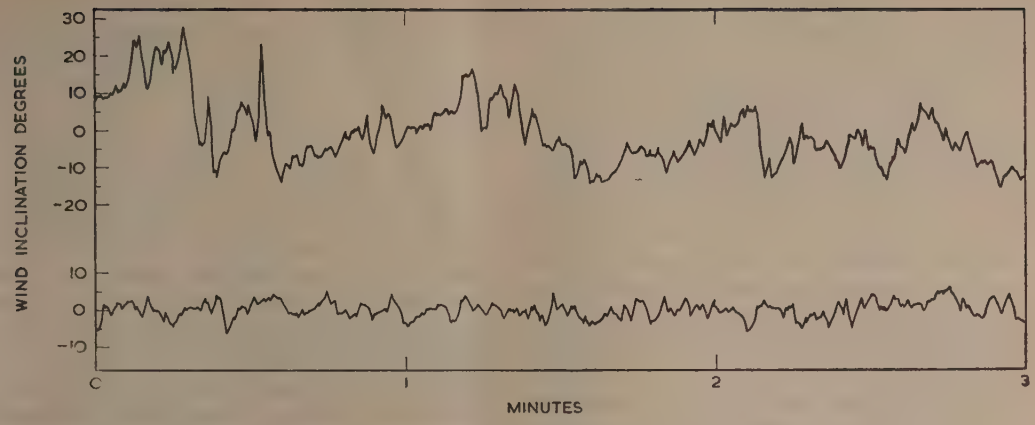

Figure 4—3-minute records of wind inclination at 29 metres; upper V = 4 metres per second in superadiabatic conditions; lower V = 3 metres per second in inversion.

These serve to illustrate by visual appeal some of the more significant features of the turbulence and its variability as discussed above. Figure 3 shows two pairs of records from sensitive elements fixed at a height of 1.5 metres, over a period rather less than two minutes, in daytime (upper pair) and night-time (lower pair) conditions at the same wind speed. The upper one of each pair shows the temperature, T, with scale of fluctuations indicated on the left of the diagram; the lower one of each shows the fluctuations of V, the horizontal wind speed. It is seen that the turbulence and associated temperature fluctuations continue to be present at night, though substantially reduced from their daytime strength. In addition we must note the exceedingly strong negative and positive correlations between T and V by day and night respectively. There is no reason for these elements *per se* to be correlated, and the explanation is to be found in their common correlation with the vertical velocity, w. A rising element by day comes from a layer where the wind is lighter and the temperature is higher, while a descending element brings stronger wind and lower temperature. At night the temperature effects are reversed while the wind effects remain unaltered, so that the sign of the correlation is reversed. The figure therefore shows indirectly the intimate association between T' and w and supports the model used in the derivation of equation 5 from equation 4.

Figure 4 shows records, from 29 metres height, of i, the inclination of the wind to the horizontal in superadiabatic and inversion conditions. In broad terms these may be discussed as if they were records of w itself, since $w = V \tan i$ and V only varies within such an interval by a fraction of its average value. The contrast in degree and also the contrast in character are to be noted. The slower fluctuations, or larger-scale elements of the turbulence, are more sensitive to the stability than the superimposed finer-grained fluctuations:— larger bodies respond more readily to buoyant influences than smaller ones. The difference in the overall intensity of w-fluctuations is at once apparent, and this is only one factor contributing to the difference in K-values since the vertical distances moved, i.e. values of l, are also much greater in the unstable case.

5. Some Comparative Results

It has been seen that the outstanding difference between atmosphere and soil as conducting media is one of degree

rather than kind, and has its basis in mobility. It follows that when deep water replaces soil as the underlying medium the mobility must be taken into account in a similar manner to that of the atmosphere. Values of the physical properties appropriate to an ocean or large water body, again in an order-of-magnitude sense, are also given in Table 2. The reduced mobility of water as compared with air results in generally lower values for the eddy conductivity K, but these are still very much larger than the corresponding values κ for solid media. For water the response of K to thermal stratification is again marked. There is no correction corresponding to the adiabatic lapse rate, Γ.

The discussion which centres on Figure 2 makes it clear that much of the variability of K in the atmosphere represents a reflex reaction according to whether heat is being supplied to, or withdrawn from, the surface. In one case the atmosphere responds by increasing, and in the other by reducing, its conductivity. With water, however, the heating is at the top and tends to produce the stable regime where the lighter water overlies the heavier; the unstable condition occurs at night. By no means all the variability in the K for water which is shown in Table 2 must be regarded as typical of diurnal variations, for with water the variations due to regional and longer-period causes play the major part due to the much higher thermal inertia or heat capacity. Nevertheless it remains a general truth, and one which is most significant in physical climatology, that the atmosphere accepts heat more readily than it gives it up whereas the converse is true of a major water body; soil, of course, remains indifferent.

Despite the wide range of K for both air and water, the ranking order air—water—soil in respect of effective thermometric conductivity is not subject to variation. Thus, from the relation of this property to the penetration, it follows that any input or outgo of energy will be distributed through a comparatively shallow depth of soil (ice, snow), through a much larger depth of free water, and through a relatively very large depth of atmosphere.

As a combination of the last two themes, we may note that the heat provided on a sunny day gets distributed through a substantial depth of air, whereas that withdrawn from it at night will be withdrawn from a much more shallow depth. The effect of wind is particularly significant here. A stronger wind will not change the order of magnitude of the already large value of K on a hot day so that the diurnal rise in surface temperature, which it will be recalled is inversely proportional to $\rho c_p \sqrt{K}$, is not greatly affected. The effect of wind on the smaller value of K at night is considerably greater and more significant: stronger winds will then substantially increase the depth from which the heat is withdrawn and will correspondingly reduce the sharp temperature fall close to the surface. Part of the action of frost fans is to produce artificially a simple increased mixing with this end in view.

6. The Sharing of Heat Between Soil and Atmosphere

Whereas we have so far considered separately the conduction of heat into soil from an assigned rate of heat supply at the surface and the similar problem in the atmosphere, the final step towards realism is to recognize that the natural process is one in which the conduction into the two media takes place simultaneously and not independently. It was previously taken that the rate of heat supply to the soil, and likewise to the atmosphere, was governed by processes (i.e. radiation, evaporation) outside our present consideration. More properly what is so determined is the sum of the two, and the ratio in which this total amount of heat is shared as between soil and atmosphere is itself determined by the conductive properties of the two media.

The two media are, as it were, in competition for the heat received during the day, and compete as providers of the heat radiated from the surface at night. It can be understood intuitively that the more successful competitor will be the one which is able most readily to conduct the heat to or away from the surface. More rigorously, since the temperature at the interface is common to both media, it follows from the principles developed in Section 2 (as modified in equation 5) that the value of $T + \Gamma z$ at any height in the atmosphere will be the same as that of T at the equivalent depth in the soil. That is to say, the profiles of $T + \Gamma z$ in the air and of T in the soil will be mirror images when the z-scales are reduced in proportion to $\sqrt{K}$ and $\sqrt{\kappa}$ respectively. The gradients will therefore be inversely proportional to these scale factors whence, from equations 2 and 5, the heat fluxes will be proportional to $\rho c_p\sqrt{K}$ and $\rho c\sqrt{\kappa}$. We may accordingly now summarize the responses of the two media in terms of three rules:—

1. The depths affected vary as $\sqrt{\kappa}$ or $\sqrt{K}$.

2. The heat flowing into or out of each will be in the ratio of the conductive capacities.

3. The surface temperature change will vary as the total heat supply (or loss) and inversely as the sum of the two conductive capacities. This sets the scale of magnitude of the temperature changes, and at other depths and heights the changes are related thereto by the pattern of behaviour described in Section 3 and Table 1.

In applying these rules we should recall the footnote in Section 5 that the assumption of K constant with height introduces some distortion in the very lowest air layers: in the two medium treatment, the consequent distortion carries through into the uppermost levels of soil. Of more practical importance in a wider range of applications are the features which follow from the variation in K as between day and night. Reference to the conductive capacities in Table 2 shows that typically the atmosphere overlying soil will be the major partner in taking up the daytime heat supply but that the soil becomes the major partner in the night-time yield. Some results of actual calculations with various combinations are shown in Table 3, based on 10^5 and 10^3 cm^2 sec^{-1} as representative K-values for day and night conditions. This Table serves to emphasize

TABLE 3

Heat sharing and relative surface temperature changes.

Air K = 10^5 day, 10^3 night.

	Night			Day		
	Ground Share %	Air Share %	Relative ΔT	Ground Share %	Air Share %	Relative ΔT
Air and new snow	20	80	4.2	2	98	1.4
Air and dry sand	52	48	2.4	10	90	1.3
Air and wet soils	80	20	1	30	70	1
Air and concrete	85	15	0.75	36	64	0.9
Air and ocean	100	0	0.005	99	1	0.014

the importance of distinguishing between heat quantities, as such, and temperature responses. Wet soils will both take up and give out a larger share of the heat than dry soils, but they will show the smaller temperature response, the latter contrast becoming particularly marked at night.

In interpreting Table 3 it must be borne in mind that the temperature comparisons relate to the same rates of sensible heat supply. Evaporation must be allowed for before comparing temperature behaviour in the same weather conditions.

The implications of Table 3 are manifold, particularly with respect to what can be done by cultivation and watering practices, etc., to induce any desired thermal effect. If we wish, for example, to increase the heat uptake of the soil during spring (when radiation provides a net surplus), three courses are open:— 1. to compact the soil, 2. to remove the vegetation (which has the same effect because vegetation is an inferior conductor to soil), and 3. to wet the soil. The third is the least reliable of these procedures because, whilst it will certainly increase the share taken up by the soil, it will also reduce the amount to be shared since more of the available energy will be used in evaporation. Consequent on the lack of symmetry between day and night in terms of temperature response (and also because of latent heat effects which are not discussed here in detail), 3 is generally effective if the immediate objective is the reduction of frost hazard, but it is less certain if a longer-period storage of heat in soil is the real intention. 1 and 2 are of more certain benefit from both the long and the short term point of view. On the other hand a loosening of the soil will allow the top layers to respond more quickly to the sun's heat, e.g. for purposes of early seed germination; at the same time it will inevitably accelerate the drying and so increase the frost risk both directly and indirectly.

7. Influence of Vegetation

In passing we have alluded to the effects of vegetation, and in conclusion we shall discuss this question briefly. It will be assumed at first that a more or less complete cover exists, i.e. that the soil surface itself is shielded from any direct radiation exchange with the sun and sky. We may then regard the vegetation as having an effective radiating surface at some level above the ground. Below this is a layer of vegetable material and air, and two cases require to be distinguished, that of a close short crop or vegetable debris or mulch in which any considerable motion of the air is impeded, and that of the open space under a canopy such as occurs in forests and allows substantial air movement.

Just as dry soil is a poor conductor in consequence of the large amount of still air filling the inter-granular spaces, in the first of the two cases above the short crop or vegetable debris is a poor conductor for the same reason. Moreover the actual material of the vegetation is itself a poorer conductor than the basic rock material of soil. The effect of a close crop or debris is accordingly that of a medium of very low conductive capacity placed immediately below the radiating surface. Greater extremes of temperature at the surface would therefore be expected, other things being equal. By day this is mitigated whenever the vegetation is freely transpiring, though the extremes are indeed experienced as soon as it dries off: it continues, however, to act as an insulator to the soil below, so that lower daytime temperatures are experienced at a given depth than would be so beneath bare soil. At night the effects of poor conduction may be observed visually, e.g. from the progressively increased incidence of frost and dew on bare soil, short grass, and long grass, in that order.

In the second case, that of the tree canopy, the effective radiating surface or level of the canopy itself will tend to be

the warmest by day and coldest at night. However some influence of wind will often be felt below the canopy. Even when the cover is thick enough to prevent this, the unequal heating and cooling will produce thermal draughts, particularly at night since this air is cooled from above and so tends towards an unstable stratification. In this case therefore, in effect a very good conductor underlies the radiating surface, and both the heat losses and gains are spread through a greater depth than normal. This results in the most equable of any land regime, not only below but at the radiating level.

No generalisations can cover the cases where the vegetation cover is partial, or highly variable, but a combination of the foregoing principles can be applied with judgement to each particular case. Temperature distributions in a number of such instances, for example at the edge of a forest, have been described by Geiger (1950).

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Book Review

Horticulture in the British Commonwealth—an Outline

By D. A. Kenhead

Commonwealth Bureau of Horticulture and Plantation Crops, T.C. 26. *Obtainable from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, C.2., Victoria. Price* 12/6d.

Summarized and indexed information received from Official Correspondents and other sources in 36 countries of the British Commonwealth and the Republics of Ireland and the Sudan throws light on the following:—

1. Crops and problems interesting the horticulturist in different lands.

2. Places where work on particular problems is in progress.

3. Leading horticultural and experimental centres in individual countries.

The Bulk Harvesting of Orchard Fruit

By G. E. Tidbury

Commonwealth Bureau of Horticulture and Plantation Crops, Digest No. 1. *Obtainable from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, C.2., Victoria. Price* 6/3d.

Helped by overseas experts the author covers practical and experimental developments in the handling of apples and other deciduous fruits and in some detail also the similar methods evolved for use in the citrus groves of Florida. The booklet is copiously illustrated and well documented.

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WC143

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THE POLL MERINO

C. H. S. DOLLING

The increased popularity of the Poll Merino, evident since the war, shows no sign of abating. The number of registered Poll Merino studs has risen from two in 1946 to 27 in 1956 and 102 in 1957, with a corresponding increase in the number of stud Poll Merino rams offered for sale. The number of shows with Poll Merino classes has also increased.

Reasons for Popularity

Those interested in the spread of Poll Merinos give numerous reasons for considering polled rams superior to horned rams, though there have been no suggestions that polled ewes are superior to horned ewes in wool or lamb production.

Head Strike by Blowfly

Polled rams are claimed to be less susceptible to head strike than horned rams, especially those with horns growing close to the head. Wool adjacent to the horn site remains wet longer on horned heads than on polled, and consequently is more attractive to the sheep blowfly. Head strike not only means added costs for prevention or treatment; severe strike may also affect the fertility of the ram.

Evidence presented by Kelley (1951) confirms general experience that the incidence of head strike is lower in polled rams than in horned. This advantage of polled rams was lessened when the insecticides dieldrin and aldrin first appeared, with their promise of long-term protection against flystrike. It is now evident, however, that there are strains of the sheep blowfly which are resistant to dieldrin (Shanahan 1958), so we may expect that these insecticides will become less effective. New insecticides with great initial effectiveness are likely to be developed, but it is also likely that the importance of blowfly strike will continue to wax and wane unless some radically different method of combating the fly is developed. This being so, sheep with a low predisposition to flystrike are desirable, and the majority of polled rams will continue to have an advantage over horned rams in this respect. A very small proportion of polled rams have deep depressions on the horn sites, in which moisture could possibly be retained. While these horn sites would then be susceptible to strike as long as they remained moist, they would probably dry out more quickly than most sites growing horns.

General Productivity

Superiority has been claimed for polled rams in three aspects of general productivity—efficiency of conversion of food into wool or body tissue other than horns, fecundity, and longevity.

There is a general argument that polled rams are more efficient converters of food because initially they do not have to use a considerable amount of protein to produce horns, and subsequently do not have to use energy in carrying horns about on the end of a long lever—the neck.

The available information on the relationship of polledness to wool production is discussed in a later section. To elucidate fully the effect of horns *per se* on the efficiency of conversion of food into wool, however, it would be necessary to compare the performance of horned rams with those from which horns had been surgically removed, and there is no information on such a comparison.

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There is also no information available on the comparative longevity of horned and polled rams, nor on their comparative fecundity. A useful measure of fecundity for the ram would be the number of lambs dropped per ewe present at lambing. So many factors affect this measure, however, that a comparison of polled with horned rams would be difficult.

It is clear that there is a lack of experimental data with a bearing on the claimed improved general productivity of polled rams.

The president of the Poll Merino Breeders' Association of Australia considers that polled rams have two advantages of specific interest to stud breeders (Clapham 1958). He considers that the young polled rams are easier to nourish during their growing period, which is in keeping with the general argument outlined earlier. He reports also that a stud polled ram may be mated at 18 months of age without seriously affecting its later development. He considers that this cannot be done with horned rams.

Losses from Horn Entanglement

Any losses which may occur amongst horned rams as a result of their horns becoming caught in fences or vegetation would, of course, not be suffered by polled rams.

Handling

Polled rams are easier to handle at close quarters than are horned rams. In the lamb-marking of a polled flock there are no short, sharp horns to dig into the catcher. A butt from a horned ram while working rams in yards can be painful. It is simpler to shear a polled head than a horned head.

While no immediate economic gain may accrue from greater ease of handling, it is probable that rams would receive better general treatment as a result.

The Inheritance of Polledness

There is a simple genetic difference between polled and horned Merinos. Polledness results from the action of a dominant gene P (Dolling 1956), which has a recessive allele p.

PP males generally have depressions, with or without a small bone knob or horny growth, while Pp males display a range of types of horn site. At the polled extreme their sites resemble those of some PP males and at the other end of the range aberrant horns may be found which are only slightly smaller than the coiled horn of the horned Merino ram. Between these extreme types one finds short and long scurs. The genotype pp results in the familiar coiled horns of the Merino ram.

In the female, PP or Pp individuals have depressions in the frontal bones on the horn sites; sometimes the depressions contain small bone knobs. All pp ewes have bone knobs, sometimes with a short scur attached.

There is a third allele which produces horns in ewes. It has been named P^I, and is intermediate in dominance between P and p. Ewes with horns are either P^IP^I or P^Ip. Entire males which are P^IP^I or P^Ip are indistinguishable from pp males, but those castrated on the day of birth grow horns similar in size and appearance to the horns of ewes.

If ewes with horns, which contain P^I, are excluded from a Poll Merino breeding flock, breeding for polledness amounts to selecting for P at the expense of p.

Definitions of Poll Merinos

The Poll Merino Breeders' Association of Australia has drawn up definitions of Poll Merino ewes and rams. These definitions are suitable for use at stud sheep sales and at sheep shows. The definitions are necessarily such that quick decisions may be made in the pen on the eligibility of any sheep to be classified as a Poll Merino.

1. For a ram to be classed as a poll merino ram, it must:—

a. be sired by a merino ram or a poll merino ram out of a merino ewe or poll merino ewe.

b. have a concavity in the bone of the skull on the horn site.
A bone knob or small scur may be set in the concavity. (A scur is a horny growth not attached to the frontal bone.)

c. not have a scur or bone knob either of which measures more than one and a quarter inches in diameter across the widest part of its base.

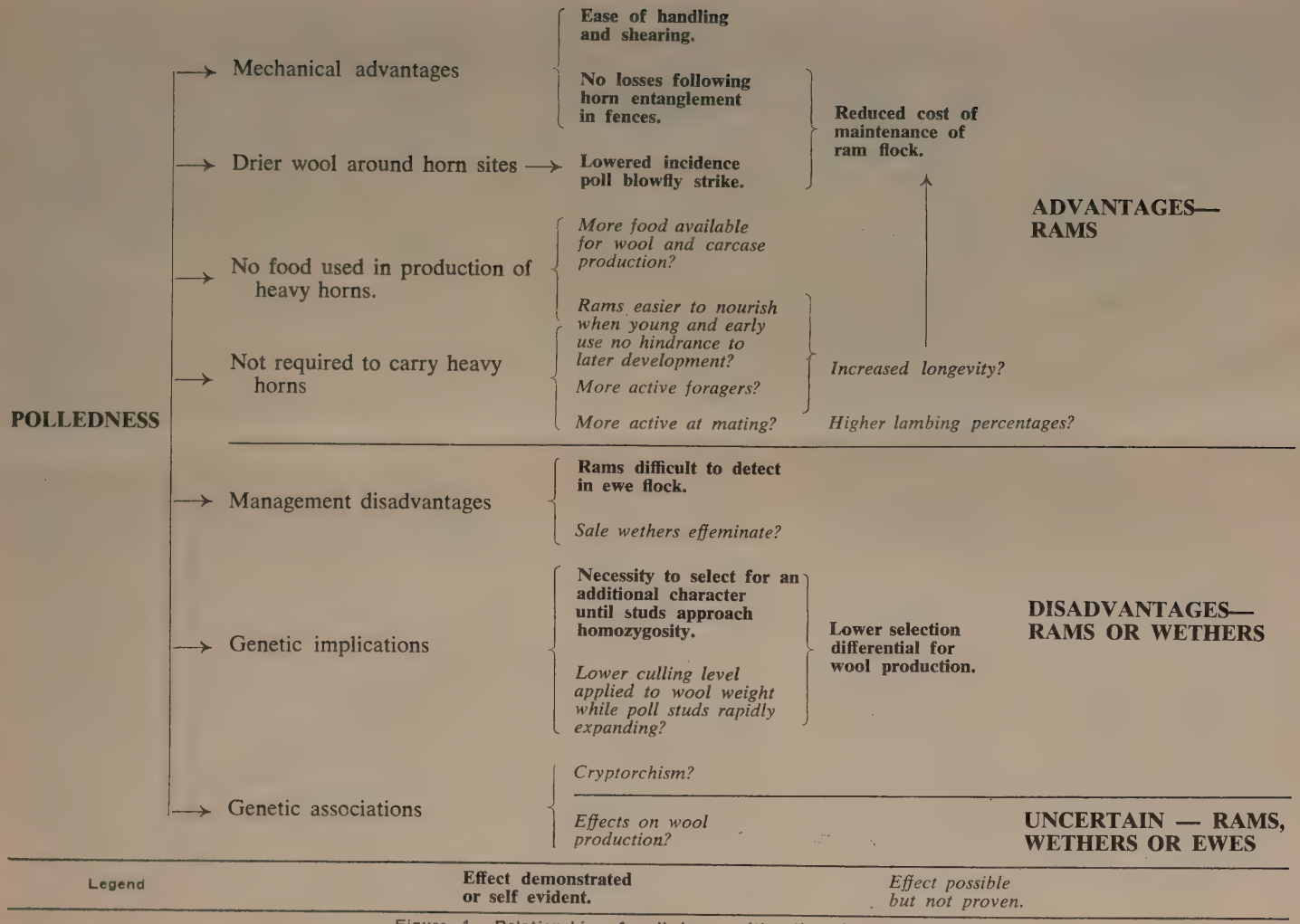
POLLEDNESS
Mechanical advantages
Ease of handling and shearing.
No losses following horn entanglement in fences.
Drier wool around horn sites
Lowered incidence poll blowfly strike.
Reduced cost of maintenance of ram flock.
No food used in production of heavy horns.
More food available for wool and carcase production?
Not required to carry heavy horns
Rams easier to nourish when young and early use no hindrance to later development?
More active foragers?
More active at mating?
Increased longevity?
Higher lambing percentages?
ADVANTAGES—RAMS
Management disadvantages
Rams difficult to detect in ewe flock.
Sale wethers effeminate?
Genetic implications
Necessity to select for an additional character until studs approach homozygosity.
Lower culling level applied to wool weight while poll studs rapidly expanding?
Lower selection differential for wool production.
DISADVANTAGES—RAMS OR WETHERS
Genetic associations
Cryptorchism?
Effects on wool production?
UNCERTAIN — RAMS, WETHERS OR EWES
Legend
Effect demonstrated or self evident.
Effect possible but not proven.

Figure 1. Relationship of polledness with other factors.

2. For a ewe to be classed as a poll merino ewe, it must:—

a. be sired by a merino ram or a poll merino ram out of a merino ewe or poll merino ewe,

b. have a concavity in the bone of the skull on the horn site.

It cannot be expected that any definition based on phenotypes will automatically include all sheep of a certain genotype, say PP, and exclude all others. However, these definitions probably do this reasonably well.

Each definition excludes all pp animals. The Poll Merino ram definition probably includes nearly all PP rams; it includes a number of Pp rams, but excludes a far greater number. The ewe definition includes both PP and Pp ewes; a number of Pp ewes are excluded—those with knobs of any type associated with their depressions.

Polledness and Economic Characters

It is possible that polledness is associated with characters of economic importance other than those already mentioned. Relationships of polledness with many characters are shown in Figure 1. Many of the relationships depicted are unproven, but an attempt has been made to consider most possibilities.

In some Continental sheep flocks there is a high percentage of cryptorchids amongst polled rams. For example, in the Prècoce breed in the U.S.S.R., cryptorchism is probably due to a recessive gene linked with a dominant gene for hornlessness (Glembockii 1941). Over 15 per cent. of all Prècoce rams studied by Glembockii were cryptorchids, mostly bilateral. Cryptorchids appear in both horned and polled Merino flocks in Australia, but it is not known whether their incidence is higher amongst the polled sheep; and there may be no link with the poll gene (P). This is likely if P appeared in our Merino flocks following migration from a polled breed not characterised by a high incidence of cryptorchism, or as a result of gene mutation on a single locus.

Whether or not the introduction of polledness is associated with any change in wool production is of current interest. It is a question which may be answered only by specific information and not by general impressions. Comparisons are required between Pp and pp, or between PP and pp animals. The two groups being compared should have been raised in similar environments, preferably in the same flock since birth. It is important that the different genotypes are not confounded with other factors as would be the case if all Pp sheep were sired by one group of rams and all pp sheep by a different group.

Comparing Polled and Horned Sheep

The most satisfactory method of comparing Pp with pp sheep is to compare the polled with the horned offspring of Pp sires joined to pp ewes. Comparisons may be made between the two groups of half-sibs, whose major difference is the presence or absence of P. This has been done with medium Peppin Merinos at the Trangie Agricultural Experiment Station by Dun (1958). He found that Pp ewes cut 4.5 per cent. less clean wool than their pp half-sisters, and hypothesised that the poll gene P was deleterious when introduced into the background genotype of a horned Merino flock. The Pp rams, however, cut 4 per cent. more clean wool than their pp half-brothers He considered that the general deleterious effect of P was here masked in Pp rams by the benefits arising from the loss of the large ram horns.

The same method applied to a different flock of medium Peppin sheep, however, has shown that in this flock the introduction of P is not deleterious to wool production (Dolling and Carter, unpublished data). The differences in wool production between polled and horned sheep, therefore, may have to be determined for any particular flock being graded to polledness. The first mating of Pp rams to pp ewes would yield sheep on which to make the test if the rams were joined singly.

It is more difficult to compare satisfactorily PP sheep with either Pp or pp sheep. Such a comparison is important, however, because any effect on wool production of P in homozygous form may differ from its effect in heterozygous form.

In a horned Merino flock are found ewes with female horns (P^lP^l or P^lp), and ewes without horns (pp). The latter have knobs or scurs. In a medium Peppin flock described by Turner (1958) which contained appreciable numbers of ewes with horns, no differences in wool production or in a number of other characters have been demonstrated between ewes with and without horns (Dolling and Carter, unpublished data).

Should Pp ewes produce less wool than their pp half-sisters in a particular flock, there is no indication that the presence of P would prevent effective selection for wool weight in the flock thereafter. Moreover, the ultimate ceiling of wool weight of a flock need not necessarily differ whether it remains horned or becomes polled. The selection applied for increase in wool weight in a polled flock could feasibly redistribute the background genes to P so that they would not interact unfavourably with P. If this settling down process were necessary it would take longer for selection to raise wool production to the same degree in a polled flock than in a flock to which P had not been introduced.

On the other hand, should Pp ewes not produce less wool, no selection would be required to bring them back to the production level of pp ewes in a programme of grading to polledness.

More work is required to determine whether polledness affects production in different strains of the Merino. If polledness does affect any form of production it will be important to know how the effect is produced.

Disadvantages of Polledness

There are two disadvantages which are direct results of polledness itself which have not been mentioned.

The first is that a stray polled ram may be very difficult to detect in a flock of ewes. Unless it were known that a ram was missing and an active search were made, the ram could remain undetected for months, especially under extensive grazing conditions, and a crop of out-of-season lambs would follow. Branding of rams reduces the risk, but even a branded polled ram is still more difficult to detect than a horned ram.

A second possible disadvantage at the present time is that the absence of horns from a flock for sale wethers may affect the price realised because the buyer may consider them effeminate. As the numbers of polled wethers increase and sheep-men become accustomed to them, this disadvantage will lessen.

There are two disadvantages which are not direct results of polledness as such. In a flock in which selection for, say, wool production per head is practised, the annual improvement is lowered either by a decrease in the selection differential or by an increase in the generation interval. In Poll Merino studs it is possible that the selection differential, or intensity of selection, for wool production could be lowered for one of two reasons.

If the demand for flock Poll Merino rams increases suddenly, Poll Merino studs could strike difficulty in maintaining their culling level and at the same time supplying the number of rams required by commercial breeders. Any temporary lowering of the standard of culling would be corrected once the demand for polled rams stabilised, and the number of stud breeding ewes increased sufficiently. This effect of a temporary drop in selection differential is to be expected whenever a gene is being spread rapidly through a population.

The second reason for a lowered selection differential available for wool production is the wastage of rams not classifiable as Poll Merinos. These may be either horned pp rams born when two heterozygotes mate, or Pp rams which grow aberrant horns. Both of these groups must be culled before rams are selected for use in the stud or for sale as stud rams. This initial selection on horn type reduces the amount of selection which may be expended on wool production. The amount of selection differential wasted on horns, as it were, decreases as the flock approaches homozygosity for P.

There need be no objection to using Pp rams with long scurs as flock rams—they have the advantages of polledness if their scurs are sawn off.

Polled and Horned Rams in Different Districts

No consideration has yet been given to the relative performances of polled and horned rams in the different environments in which Merinos run. It is possible that the disadvantages of horned rams may not be serious in some districts but very important in others. If so, polled rams would be especially advantageous in the latter districts.

An experiment designed to study such special adaptation of a type of sheep to a particular environment has been reported (C.S.I.R.O. Annual Reports, 1955 and 1956). The wool and lamb production of five Merino strains was compared in three environments—Deniliquin, Armidale and Cunnamulla—and although interactions between strain and environment were real, they were too small and too variable from season to season to be important in deciding on the class of sheep to be run in a given area.

Two exceptions to this general conclusion, however, were the real adaptation of the fine non-Peppin strain to the tableland environment at Armidale, and the very high incidence of fleece rot of the strong non-Peppin strain in the same environment. (Dunlop and Hayman 1958).

One may conclude that while special adaptations of Merino types to different environments may not be of great general importance, they may be important in specific cases. It is not difficult to visualise that in a severe fly-strike area horned rams would require more attention than polled rams over the years; in this event polled rams would cost less to maintain as far as fly-strike is concerned. On the other hand, this advantage would be less in an area where blowfly waves are fewer and less intense.

Similarly, it could be that any advantage of polled rams in general productivity would manifest itself more readily under adverse nutritional conditions—during a drought, or in areas of low carrying capacity.

It is not known whether interactions such as these between horn type and environment do exist, but their possibility should be taken into account when considering the Poll Merino.

Effects of Poll Merino Increase at Different Levels in Sheep Industry

The attributes of the Poll Merino discussed may affect the commercial wool producer, the stud breeder, and the whole Australian Merino flock to different degrees. The most important relationships between these attributes and the different levels in the sheep industry are summarised in Figure 2.

Any reduction in the cost of maintenance of a ram flock and the possible improvement in rams' general productivity would affect all levels. Those who handle rams—stud and commercial breeders, and shearers—benefit from the greater ease of handling.

If a lowered culling level were applied in a rapidly expanding polled stud, this would not be felt by the stud breeder in that ram sales would not necessarily drop. Nor would it affect the buyer of better quality flock rams. The flocks of those who buy lower grade flock rams, which would normally have been culled, would be affected. As a consequence, so would the whole Merino population.

The necessity to select for an additional character would be felt primarily by the stud breeder—he would have fewer rams for sale. The commercial breeder need not buy cryptorchids. Cryptorchism could, however, be increased and become a problem at castration should it be recessive and linked with polledness.

Difficulty of detection of rams in a ewe flock would be a hazard to all breeders. The possible disadvantage of sale wethers being considered effeminate would be felt only by the producer of wethers, the commercial breeder.

Summary

There has been a great increase in the popularity of Poll Merinos since the war. The advantages claimed for Poll Merinos relate to rams only. They boil down to a reduction in the cost of maintenance of a ram flock,

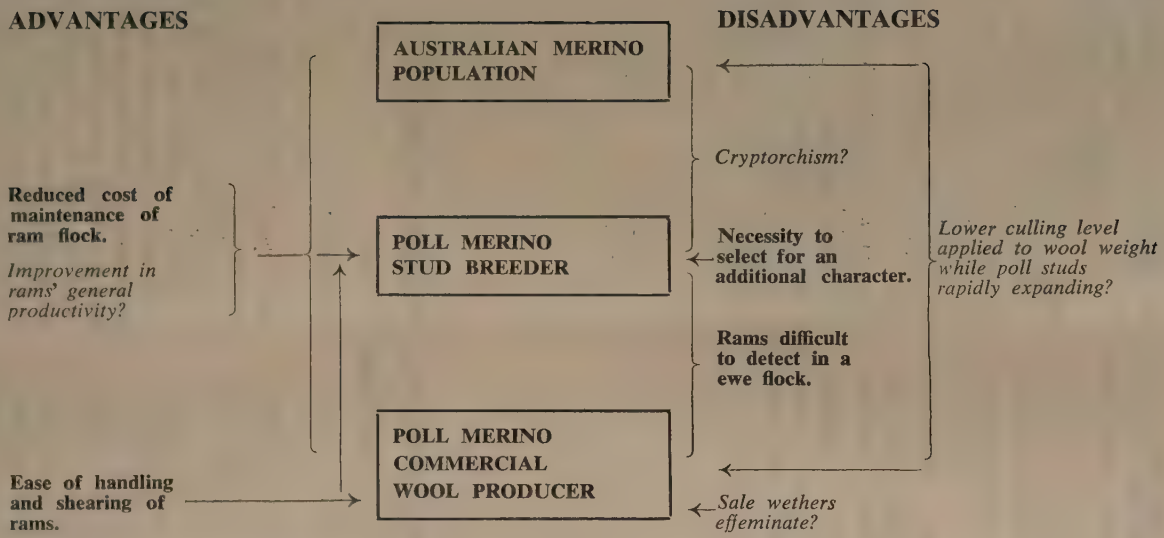
ADVANTAGES
DISADVANTAGES
AUSTRALIAN MERINO POPULATION
Cryptorchism?
Reduced cost of maintenance of ram flock.
Improvement in rams' general productivity?
POLL MERINO STUD BREEDER
Necessity to select for an additional character.
Lower culling level applied to wool weight while poll studs rapidly expanding?
Rams difficult to detect in a ewe flock.
POLL MERINO COMMERCIAL WOOL PRODUCER
Ease of handling and shearing of rams.
Sale wethers effeminate?
Legend
Effect demonstrated or self evident.
Effect possible but not proven.

Figure 2. Major effects of increase in number of Poll Merino sheep at three levels in Australian Merino population.

largely because of the polled rams' low predisposition to head strike, and a greater ease of handling of the polled ram.

Other things being equal, polledness is a good thing. However, temporarily at least, the rate of improvement in wool production through selection may be lowered as a result of a smaller selection differential. However, the ultimate ceilings of wool production reached by flocks graded to polledness may not differ from those of horned flocks.

The association of polledness with many economic characters is not yet clear, and more information from numerous flocks is required.

The procedure of breeding for polledness is that of increasing the frequency of a dominant gene by selection once the gene P has been introduced from another flock or has appeared as a mutation.

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Book Review

THE CONSERVATION OF NATURAL RESOURCES

By Richard C. Haw

Faber and Faber Ltd., London, 1958.

A book on the conservation of natural resources by an author from Southern Rhodesia could be an outstanding contribution to the conservation literature.

In his preface, the author states as his objective a "handbook on the conservation of natural resources" having "value as a practical guide" in which "technicalities have been reduced to a minimum."

Whether such a book would serve any real purpose is doubtful, but it is much too optimistic to expect it to be achieved in a volume of this size.

Only two chapters are devoted to the conservation of resources other than soil, and for this reason it can hardly be considered a "handbook on the conservation of natural resources".

Even as a book on soil conservation it is disappointing. The author has failed to expound the basic concepts and principles with sufficient precision and clarity, in fact some of the statements will be disputed. Although the details of some methods of erosion control are given, little or no reference is made to the basic principles which govern the selection of the appropriate method or the variations in the designs of methods required for different sets of circumstances.

One feels that the author has attempted to cover too broad a subject with too few words. A much more valuable contribution to the conservation literature would have resulted if he had written a detailed and precise account of soil erosion and the methods for its control in Southern Rhodesia, and of the excellent work being done there for the conservation of soil and water.

R. G. DOWNES

SORGHUM ALMUM PARODI — A VALUABLE SUMMER-GROWING PERENNIAL GRASS

J. GRIFFITH DAVIES and
L. A. EDYE

In recent years a new species, *Sorghum almum* Parodi, has gained world-wide recognition as a highly productive perennial forage sorghum. It was first introduced into Australia from Argentina by C.S.I.R.O. in 1946, and its value as a forage plant for drier areas of north western New South Wales was soon realised. *S. almum* was declared a "prohibited seed" in Queensland (Queensland Government Gazette, December 16, 1954) and a "noxious weed seed" in New South Wales (New South Wales Government Gazette, March 16, 1956). It was prohibited in Queensland because it was potentially toxic, difficult to eradicate, and its seed could not be readily distinguished from *S. halepense* (L.) Pers. (Johnson grass) seed (Anon 1955). However, rapidly increasing numbers of graziers continue to use the species and the large quantities of seed being produced cannot satisfy the demand.

In the United States of America *S. almum* is also a "controversial" grass. Some States have banned it, others are cautious, while it is highly regarded in Oklahoma, Texas and New Mexico. In Argentina and the Union of South Africa certified *S. almum* seed is available to farmers and the species is being rapidly assimilated into agricultural practice. This paper reviews the overseas and Australian experiences with *S. almum* in order to assess the present position.

Description

Sorghum almum is a natural hybrid which originated in Argentina and was first described by Parodi (1943). Parodi (1946) recognized three varieties, viz. *typicum, parvispiculum* and *randolphianum*. *S. almum* resembles *S. halepense* in being rhizomatous and having 40 somatic chromosomes. However, it differs from *S. halepense* in having taller and thicker stems, broader leaves, shorter rhizomes which curve upwards and are not invading, and larger panicles with the sessile spikelets attached to the pedicel and larger caryopses. *S. almum* resembles *S. vulgare* var. *sudanense* (Hitchc.) (common Sudan) and *S. arundinaceum* Stapf. (Cameroon grass) in aerial organs but differs from these two species in having rhizomes. Sudan grass and Cameroon grass are annuals with 20 somatic chromosomes. Parodi (1943) suggested the hybrid origin of *S. almum* and thought *S. halepense* was one of its parents.

S. almum is a summer-growing perennial which is extremely vigorous and which gives high yields of forage suitable for grazing, hay, and ensilage. Growth usually occurs early in spring and it flowers from December to April. Stands can reach a height of 10 to 12 feet with stems half an inch in diameter at ground level. Pastures can be heavily stocked within six weeks of sowing under favourable growing conditions. Although very coarse, the grass is extremely palatable at all stages of growth and

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is readily grazed to ground level by sheep and cattle with little wastage of fodder by trampling.

The green leaf of *S. almum* is very susceptible to frost damage, and the thick stems, although more resistant, eventually succumb. *S. almum* remains relatively palatable and nutritious even when frosted and it can provide valuable winter standover grazing. It has a high seed yielding potential and only a small proportion of the seed is shed at maturity. The unshed seed helps maintain the food value of *S. almum* when frosted.

S. almum initiates new growth primarily from nodal buds at ground level with a few new shoots from rhizomes. It will make some growth during relatively warm mid-winter days which are not infrequent in Queensland.

Introduction and Adaptability

S. almum had been widely cultivated in Argentina for ten years under the common name sorgo negro (black sorghum) before it was described by Parodi in 1943. At present over 200,000 acres have been sown mainly in the Provinces of Cordoba, Santa Fe, San Luis, Santiago del Estero and Chaco. The Ministry of Agriculture certifies *S. almum* seed to avoid contamination from *S. halepense* seed and recommends its use in areas with a maximum annual rainfall of 28 inches (Bignoli, personal communication 1958). It is recommended for marginal land merging into desert (Ledesma and Ledesma, personal communication 1947). Ragonese (1951) states that it is the most important forage plant used in the Salinas Grandes, an ancient salt lake in semi-arid Central Argentina. *S. almum* is drought resistant and salt tolerant and is primarily a pasture plant for semi-arid environments.

Its outstanding productivity and adaptability underlies its successful introduction and utilization in other countries. *S. almum* was first introduced into the Union of South Africa in 1946 from Messrs. De Ledesma of Argentina. It was later re-introduced in 1949 from the same source. Mother seed of this later introduction has been commercially multiplied and certified after rigorous inspection by Department of Agriculture officers. It is recommended for use in areas with 16 to 24 inches annual rainfall on the heavier, more fertile, soils, (Chief, Division of Crops and Pastures, South African Department of Agriculture, personal communication 1958). It is well suited to the lower rainfall areas of the Eastern Cape, Western Transvaal and Western Orange Free State (Liebenberg, Preller and Mostert 1954).

S. almum has been introduced into the United States of America from Argentina, South Africa, Australia, New Zealand, Nigeria and Algeria. It has been included in trials at Texas since 1946 (Anon 1957*b*). It shows promise in Georgia where it survived a winter minimum temperature of 4°F (Morrison 1953) and also in the south west, particularly Oklahoma, Texas and New Mexico (Thompson, personal communication 1957). *S. almum* has been banned in Kansas because it might become a weed of cultivation and also endanger seed production of Sudan grasses and sorghums (Anon 1957*b*). It will not survive winters in Kansas and is considered inferior to Sudan grass as an annual forage crop (Anon 1957*a*). It has been designated a noxious or prohibited weed seed in Arizona, California, Indiana, Nebraska and Missouri, and Colorado is in the process of deciding what action to take (Anon 1958*a*). Virginia has also prohibited use of *S. almum* (Anon 1958*b*).

Many strains of *S. almum* have been introduced into Australia since 1946. The C.S.I.R.O. introductions are listed in Table 1.

S. almum C.P.I. 9840 was first included in an experiment which was sown at Curlewis, New South Wales, in September 1947. Over a four year period it proved the most productive of all grasses being evaluated. However, in the fifth year it rapidly declined in production. In September 1949 a further experiment was sown at Curlewis which included two strains of *S. almum,* viz. C.P.I. 9840 and C.P.I. 12019. They performed equally well in the first year but C.P.I. 12019 showed better persistence and greatly outyielded C.P.I. 9840 in succeeding years. Strain C.P.I. 12019 had finer stems and more tillers and was selected for wider regional testing (C. A. Neal-Smith, personal communication).

During the 1950-51 season, C.P.I. 12019 was sown at a number of localities including

TABLE 1

Commonwealth Scientific and Industrial Research Organization Accession of Sorghum Almum

C.P.I.	Date Received	Source	Notes
9840	March 5, 1946	L. R. Parodi, Buenos Aires, Argentina	var. typicum. Seed from the Botanic Garden of the Faculty of Agronomy
10179	December 10, 1946	Australian Scientific Liaison Office, London, England	SRL 3567
12019	October 8, 1948	F. X. Laubscher, Potchefstroom, South Africa	No details
18181	November 26, 1953	J. V. A. Nehemiah, New Delhi, India	S 342
18384	June 10, 1954	R. D. Rodriquez, Buenos Aires, Argentina	"Sorgo Negro". Selection with short rhizomes
19590	April 13, 1955	F. Bulcock, Australian Scientific Liaison Officer, London, England.	Origin of seed uncertain. Believed to be commercial seed from Argentina
22024	February 6, 1957	L. Sauger, Bambey, Senegal, West Africa	No details
22550	April 15, 1957	R. P. Celarier, Oklahoma, U.S.A.	A 2781. Originally from Argentina
22551	April 15, 1957	R. P. Celarier, Oklahoma, U.S.A.	A 4836. Originally from Argentina
23181	July 3, 1957	E. C. Farinas, Manila, Philippines	
23182	July 3, 1957	E. C. Farinas, Manila, Philippines	FC 33015. (Presumably originally from U.S.A.)
23683	December 12, 1957	Division de Exploraciones e Introduccion de Plantas, Ministerio de Agricultura, Buenos Aires, Argentina	DEIP 2125. Sorgo negro. From the Jardin de Aclimatacion Yerua, Colonia Yerua, Entre Rios, Argentina
24258	April 17, 1958	Centre de Recherches Agronomiques, Bambey, Senegal, West Africa	Received through Dr. Hutton. Probably identical with C.P.I. 22024.

Mr. O. C. Uebergang's property at Crooble, New South Wales. Mr. Uebergang wished to develop the strain commercially and harvested seed from small experimental plots in May 1951. Two years later he harvested 70,000 lb of seed. Some of this seed was sold to graziers in Queensland and New South Wales.

In the 1951-2 season the three *S. almum* strains, C.P.I. 9840, C.P.I. 10179 and C.P.I. 12019 were sown by Mr. W. G. Robertson in an experiment at the Cooper Laboratory, Lawes. Seed from one of these strains was sent to Mr. B. C. Carr Clark of "Nunbank", Taroom. There is no record of which strain was harvested. Mr. Carr Clark made seed available commercially in 1954 and sold a considerable amount before the species was prohibited. The "Nunbank" strain of *S. almum* seems different from the "Crooble" strain, being taller, coarser, more palatable with fewer rhizomes, but is much less persistent. It is likely that the two strains have had different origins.

Potential Use in Australia

S. almum has been successfully grown under irrigation at Deniliquin (33.5°S.) so it may have use as an irrigated summer pasture in winter rainfall areas. However, it is most suited to areas of predominantly summer rainfall with an average annual precipitation of 18-30 inches. It will grow on soils ranging in texture from sands to heavy clays, but demands a deep soil of high fertility. *S. almum* is adapted to the fertile soils of the following broad agronomic regions of north-western New South Wales and sub-tropical and tropical Queensland.

Natural Grasslands

1. The black earths of the Darling Downs carrying a native pasture of predominantly blue grass (*Dichanthium sericeum* (R.Br.) A. Camus). Area 5 million acres and an annual rainfall of 25 to 30 inches.
2. The black earths of the open downs in the Central Highlands of Queensland. Native pasture predominantly blue grass. Area 2.7 million acres and rainfall 25 to 30 inches.
3. The grey and brown soils of heavy texture of the Mitchell grass (*Astrebla* spp. F.v.M.) downs. An area of 15 million acres lies between the 15 and 20 inch isohyets in Queensland. *S. almum* has persisted six years on these soils at Richmond (20.7°S. and 18.3 inches annual rainfall).

Scrubs

The grey and brown soils of heavy texture supporting:—

1. Brigalow (*Acacia harpophylla* F. Muell.) associations including belah (*Casuarina lepidophloia* F. Muell.), wilga (*Geijera parviflora* Lindl.), box (*Eucalyptus populnea* F. Muell.), yapunyah (*E. thozetiana* F. Muell. ex R. T. Bak.), and yellowwood (*Terminalia oblongata* F.v.M.) in varying degrees of dominance. Area 23 million acres and rainfall 20 to 30 inches.
2. Gidyea scrubs (*Acacia cambagei* R. T. Bak.) with an annual rainfall of less than 20 inches. Area unknown.

S. almum will grow well on fertile alluvial soils including recent alluviums and weakly solonized older alluviums carrying box and coolibah (*E. microtheca* F. Muell.). However, established plants of *S. almum* will not survive flooding. At North Star, New South Wales, it has persisted and spread along flood plains of streams by re-establishing from self sown seed following the receding summer floods.

S. almum is unsuited to the soils of low fertility including solods, solodized solonetz and skeletal soils, which carry bull oak (*Casuarina leuhmannii* R. T. Bak.), cypress pine (*Callitris glauca* R.Br) and narrow leaved iron bark (*Eucalyptus crebra* F. Muell.).

Cultural Practices

Establishment

S. almum has a large seed which germinates readily and the seedlings are very vigorous. These attributes ensure establishment on all soil types even in dry seasons. Great difficulty is often experienced in establishing small seeded improved pasture species such as Rhodes grass (*Chloris gayana* Kunth), green panic (*Panicum maximum* var. *trichoglume* (K. Schum.) Eyles) and buffel grass (*Cenchrus ciliaris* L.) on self-mulching black earth of the Darling and Central Highland Downs and also some brigalow soils. However, *S. almum* can be easily established on these soils by sowing after cultivation or by broadcasting seed on ashes after burning pulled brigalow scrubs. The best time to plant *S. almum* in Queensland is after heavy rain falls during January to early March. Spring plantings are possible in north-western New South Wales.

Mixtures

In north western New South Wales and the southern border districts of Queensland, the annual medics *Medicago denticulata* Willd. (burr medic) and *M. minima* (L.) Bartal (small woolly burr medic) are naturalised on calcareous soils. These medics have volunteered in *S. almum* pastures at Crooble, North Star and Goondiwindi. While *M. minima* lacks vigour and is not as productive, *M. denticulata* makes excellent growth during favourable seasons. *S. almum-M. denticulata* pastures have carried more than one beast per acre per annum for seven years at Crooble. Andrew and Hudson (1954) have found barrel medic 173 (*M. tribuloides* Desr.) superior to other annual medics at Crooble.

Lucerne (*Medicago sativa* L.) and *S. almum* have produced an excellent pasture on well drained soils at Goondiwindi and Taroom. They can be successfully established when sown together during January to early March at seed rates of 1 lb and 5 lb per acre respectively. Stock selectively graze *S. almum* during the summer months but prefer lucerne after the *S. almum* is frosted. Lucerne survives the competition for light during the summer growing season when *S. almum* may attain a height of 8 to 10 feet. Lucerne makes most growth during autumn and maintains production through the relatively dry winter and spring months by exploiting sub-soil moisture reserves

which have been conserved from excess summer rain.

Because *S. almum* demands high levels of nitrogen, the grass is most successfully exploited when grown in association with legumes on deep fertile soils such as rendzinas, black earths and grey and brown soils of heavy texture. In addition to lucerne and annual medics some perennial, twining, summer growing tropical legumes in the genera *Phaseolus* (L.), *Glycine* (L.) and *Vigna* Savi. look promising for inclusion in mixtures with *S. almum*. However, further wide scale regional testing is required to elucidate their adaptability and productivity under grazing before any recommendations can be made.

Fertilization

As stated earlier, there are 46 million acres of black earths and grey brown soils of heavy texture in Queensland between the 15 inch and 30 inch isohyets which possess high natural fertility and which are suitable for growing *S. almum*. These soils mainly support native pastures of low productivity or unproductive virgin brigalow, gidyea or soft wood scrubs, with a very small area being cultivated for annual crops. While nitrogen probably limits the growth of improved perennial pastures on all these soils, other plant nutrients are rarely deficient. Some grey and brown soils of heavy texture supporting brigalow scrub association tend to be low in phosphate (Davies, Edye and Sanders, unpublished data). Improved pastures can be established on these soils without use of fertilizer but their success depends mainly on the maintenance of suitable legumes in the pasture while it remains uneconomical to use nitrogenous fertilizers. In the Union of South Africa, the application of heavy rates of nitrogenous fertilizers to *S. almum* growing on a phosphate deficient soil greatly increased the HCN content of the *S. almum*. The correction of the phosphate deficiency reduced the HCN content (Penzhorn 1956).

Management

S. almum pastures are used primarily for summer grazing in north western New South Wales and southern Queensland where frosts are frequent during winter months. The pastures are stocked at two or three cattle per acre during September to April and utilized mainly before the first frosts. Stock are then carried on lucerne or oats that is grown following a summer fallow, the stock being allowed access to the remaining *S. almum* roughage in an adjacent paddock. Even after frosting *S. almum* remains palatable and nutritious, and pastures reserved for over-winter feeding can maintain stock in good condition, especially when the mixture includes annual medics or lucerne.

Providing water is not limiting, *S. almum* shoots vigorously early in September when the availability of feed of high quality is often critical for the survival of animals. It can be grazed two or three weeks before native pastures have made sufficient growth for grazing. Following grazing in spring, *S. almum* may be cut for hay or silage in January or February and the aftermath later grazed.

Both sheep and cattle graze *S. almum* readily even if it is eight to ten feet high. Sheep defoliate stems to sheep height and then graze higher leaves, fine stems and seed heads by straddling tussocks and bending stems to ground level under their bodies.

Seed Production

S. almum flowers from December to April. There is very little shedding of seed after ripening and the seed is usually harvested following frosts. Standard header-harvesters can be used for harvesting but the height of the crop presents some minor difficulties. Yields of seed up to 1,400 lb per acre have been obtained. Seed is priced at about one shilling to two shillings per pound (compared with Rhodes grass, four and sixpence, green panic, ten and sixpence, and buffel grass, sixteen shillings per pound) and this is an important economic consideration, especially in the large scale establishment of pastures on brigalow scrub burns.

Productivity

Considerable areas of *S. almum* pastures were planted from Inverell to Richmond, Central Queensland, before sale of seed was pro-

hibited. The experiences of some graziers are recorded below.

Mr. O. C. Uebergang of Crooble has 560 acres of *S. almum* and volunteer *Medicago denticulata* pasture which fattens more than one beast per acre throughout the year. The pasture has shown no decline in productivity since planted in 1950. Mr. Doolan of North Star has 140 acres of a similar pasture planted in 1951. In a good season this pasture has fattened two cattle per acre in the nine months from September to May inclusive. Mr. W. Gunn of "Tarewinnabar", Goondiwindi, uses 120 acres of *S. almum*-lucerne pasture in conjunction with 480 acres of native pasture. In 1957, the driest year since 1944, 400 two and a half year old steers were fattened during April and May and 600 ewes and their lambs were carried for the succeeding 10 months. The stock rarely grazed the native pasture. Mr. B. C. Carr Clark of "Nunbank", Taroom, has 100 acres of *S. almum* which is utilized in conjunction with 500 acres of native pasture. This paddock fattened 415 three to three and a half year old steers over the 10 months period August 1954 to May 1955. The stock concentrated on the *S. almum*.

Mr. Carr Clark's pasture was planted on alluvial soil which originally carried box and coolibah. The other pastures were on soils which originally carried mixed brigalow and belah scrub. The stock carrying capacity of native pastures on similar soils would be approximately a beast to seven acres or less than one sheep per acre.

S. almum-M. denticulata pastures at Crooble and North Star have increased carrying capacity more than sixfold, yield of animal products per acre probably showing an even greater increase. Increases in production have been obtained at Goondiwindi and Taroom by using improved pastures in association with native pastures. However, the contribution of the latter, although thought to be small, cannot be assessed. *S. almum*-lucerne pasture at Goondiwindi gave high production during a dry season and survived heavy stocking. Experimental *S. almum* pastures at Taroom have yielded 5 tons 17 cwt of dry matter per acre twelve weeks after planting on a fallow on December 22, 1955.

Toxicity

Most sorghums, including *S. almum*, contain the glucoside dhurrin which yields free Hydrocyanic acid (HCN), when the glucoside is hydrolysed following bruising, cutting or defoliation of the plants by animals. Young shoots of both primary and secondary growth contain the highest concentration of this glucoside. Stunting of growth by prolonged drought, nutrient deficiencies, insect damage or frosting causes increased glucoside in all plant parts. It is generally considered that the glucoside content of the material ingested, the rate of ingestion, and the rate of hydrolysis of the glucoside in the rumen are important factors in toxicity (Coop 1951).

After eight years of cultivation in Australia only three probable cases of stock losses from grazing *S. almum* have been recorded. These losses are insignificant in comparison with the number of cattle fattened. During 1953 two cases were recorded in New South Wales. At Moree ten dairy cows died after grazing drought stunted pasture only 4 to 13 inches high, three months after establishment. At Ashford ten in calf dairy cows succumbed from grazing drought stunted pasture while three cows not in calf survived. In the latter case it is suspected that the stock were very hungry when depastured, (Sharp, personal communication). The year 1953 was very dry and stock losses occurred from grazing other species of sorghum (Hartley, personal communication). During 1958, *S. almum* was suspected of killing sheep at Richmond, Queensland, after grazing drought stunted pastures 8 inches high (Skerman, personal communication). However, many graziers have found that stock being continuously carried on *S. almum* can safely graze drought stunted or frosted pasture. The greatest danger occurs when stock, because of the extreme palatability, graze greedily. On introducing stock to *S. almum* they should be depastured with their appetites fully satisfied. *S. almum* has been extensively cultivated in Argentina, the Union of South Africa and Australia, and it is

generally agreed that it can be safely grazed provided hungry stock do not gain access to droughted material, especially when it is less than 14 inches high during establishment.

In prohibiting *S. almum* in Queensland, it was considered potentially more toxic than improved varieties of forage sorghum and Sudan grass (Anon 1955). On the basis of HCN content alone, Hutton has found only minor differences in the range of variation in individual plants of *S. almum* and other varieties of sorghum (see Table 2).

In Argentina the decreasing order of toxicity of cultivated sorghums is considered to be *S. caffrorum* (Retz.) P. Beauv. (most toxic), *S. technicum* (Koernicke), *S. saccharatum* (L.) Moench, *S. almum, S. halepense,* and *S. sudanense* (Piper) Stapf (least toxic), (Bignoli, personal communication 1958).

Weed Potential

It is generally agreed in Argentina, the Union of South Africa and Australia that *S. almum* is not an invading plant and in this respect is radically different from *S. halepense,* an aggressive weed of cultivation. Viable *S. almum* seed spread by man, water, or in stock droppings will volunteer on fallowed land or on any mechanically disturbed soil. It may also establish in native pasture weakened by drought or flood, but isolated plants fail to persist unless protected from selective overgrazing, because of its extreme palatability and low plant density.

In lower rainfall areas *S. almum* is regarded as a short lived perennial which can be controlled by heavy grazing and easily eradicated by a single ploughing. In 28-31 inch rainfall areas of Argentina, stands become very thin after four or five years (Bignoli, personal communication 1958) and *S. almum* has been referred to as "five year sorghum" (Anon 1946; Rojas 1946). Liebenberg, Preller and Mostert (1954) consider that the productive life of *S. almum* is six years in parts of the Union of South Africa. In Australia *S. almum-Medicago denticulata* pastures have maintained their productivity for eight years as Crooble, New South Wales, (21 inch rainfall). In the absence of improved pasture legumes *S. almum* has persisted five years at Taroom (26 inch

TABLE 2

Percentages of plants in progenies with different amounts of cyanogenetic glucosides

Variety	Percentage of Plants				No. of plants tested
	200-280 p.p.m. HCN*	400-560 p.p.m. HCN*	600-850 p.p.m. HCN*	1200-1700 p.p.m. HCN*	
Sumac	0.9	3.2	23.9	72.0	926
Sweet Sudan	0.7	4.0	34.7	60.6	541
Sudan	4.7	16.5	37.8	41.0	2278
Sorghum almum	3.8	14.5	28.1	53.6	7664
Milo	4.9	12.4	30.9	51.8	434
Sorghum arundinaceum	5.6	17.4	26.0	51.0	527

*Determined by the picrate paper method which was calibrated chemically with known amounts of HCN. Plants tested at three leaf seedling stage.

rainfall) and six years at Richmond (18 inch rainfall), but has rapidly declined in production since establishment.

In Argentina there is a real fear of *S. almum* as a weed of cultivation in the 40 inch rainfall agricultural areas of the humid pampa. In this region *S. almum* is not recommended for use as a ley pasture in rotation with crops such as maize, wheat, grain sorghum and linseed. *S. almum* seedlings which volunteer after the cultivation of old ley pastures compete strongly with annual crops. This seedling regeneration seems to cause more concern than the difficulty of eradicating established plants. Donald (personal communication 1958) states that the weed fear in the agricultural areas is undoubtedly based in part on the infestations of Johnson grass. The Argentina Ministry of Agriculture recommends the use of *S. almum* in areas of less than 28 inch rainfall which includes the arid shrub region of Argentina. There is no law which forbids its use in higher rainfall areas. *S. almum* is highly regarded by beef producers in the 40 inch rainfall areas of the province of Formosa (Donald, personal communication 1958).

In Australia the strains of *S. almum* in commercial use have been readily eradicated when grown in areas of less than 30 inch annual rainfall. In higher rainfall areas strains showing strong rhizome development could become very difficult to eradicate, especially if established on fertile soils in closely settled agricultural areas. Swain and de Beuzeville (1945) have delineated climatic zones in the New England region of Australia and have compared selected stations in these zones with stations in the Argentine. From these climatic comparisons and a knowledge of the regions where *S. almum* is recommended in Argentina, it seems that *S. almum* will be difficult to eradicate in zone 3.6a, can be recommended for zone 5.6a, while zone 5.6b is transitional.

Seed Identification

Musil (1957) made a comparison of the florets and caryopses of *S. almum, S. halepense,* and *S. vulgare* var. *sudanense*. In bulk samples the three species could be identified easily and in mixed samples Sudan grass could be correctly identified, but difficulty arose in distinguishing between *S. almum* and *S. halepense*. The florets of Sudan grass disarticulate by complete fracture; the caryopses are elliptical and large and the margins of the embryos are usually poorly defined, and the root-shoot axis is flattened at the top and terminates in two raised ridges towards the base. In *S. almum* disarticulation of florets is mostly by fracture, with a smaller proportion disarticulating by complete or partial abscission, while *S. halepense* florets disarticulate by complete abscission. Both *S. almum* and *S. halepense* have obovate caryopses smaller than Sudan grass; the margins of the embryo are usually well defined; and the root-shoot axis of the embryo is a thick raised ridge throughout its entire length. *S. almum* occupies an intermediate position in caryopsis size between Sudan grass and *S. halepense*. Distinction between *S. almum* and *S. halepense* can only be made on overall size of florets and caryopses and difficulty arises with florets and caryopses which may be outside their respective size ranges. Hutton (unpublished data) carried out germination tests with *S. almum* and *S. halepense* and found no differences in colour of root tip and coleoptiles, and reaction to ultra violet light.

Because of the difficulty in distinguishing between *S. almum* and *S. halepense,* contaminated *S. almum* samples would not be readily detected and wide scale cultivation of *S. almum* may enhance the spread of *S. halepense*. This possibility, which was a reason for prohibiting *S. almum* in Queensland (Anon 1955) can be avoided by certification of seed for trueness to type and purity following inspection of seed crops by Government officials. Production of *S. almum* seed should be prohibited in areas where *S. halepense* is already established. This would prevent the production of an off-type strain through interspecific hybridization with *S. halepense* and avoid admixture of *S. halepense* seed.

Cytogenetics and Plant Improvement

Parodi (1943) included *S. almum* with *S. halepense* in the sub-genus *Eu Sorghum* sub-sec-

tion *Halepensia* (Snowden 1936) because of its similarity to *S. halepense* in chromosome number (2n = 40) presence of rhizomes and spikelet characters. Parodi (1943) also showed that *S. almum* has a marked similarity to common Sudan and *S. arundinaceum* and other species of sub-section *Arundinacea* (Snowden 1936), which includes annuals or tufted perennials with 20 somatic chromosomes. Parodi suggested that *S. almum* was of hybrid origin with *S. halepense* as one of the parents. Saez and Munez (1943) and Saez (1952) concluded that *S. almum* had arisen through the union of a normal gamete of *S. halepense* with a diploid gamete of a species from the sub-section *Arundinacea*.

A few artificial tetraploid hybrids have been reported to have affinities with *S. almum*. Parodi (1946) found Randolph's Sudan grass x *S. halepense* hybrid to closely resemble *S. almum*. Tome (1954) crossed *S. halepense* with *S. caffrorum* (Kaffir grain sorghum) and *S. saccharatum* (sweet sorghum). Plants similar to typical *S. almum* were obtained in the F_2 and F_3 generations. *S. almum* types were more frequent among the progeny of the *S. halepense* x *S. saccharatum* hybrid. Endrizzi (1957) also reported obtaining plants similar to *S. almum* among F_3 segregates of a hybrid between Kaffir grain sorghum and *S. halepense* and that Bennett in Mississippi had obtained stable *S. almum* types from a *S. vulgare* x *S. halepense* hybrid. Endrizzi (1957) in a cytological study of some species and hybrids in the *Eu Sorghums* concluded that a grain sorghum type rather than Sudan grass crossed with *S. halepense* to produce *S. almum*.

Huskins and Smith (1932), Duara and Stebbins (1952), Hadley (1953), Krishnaswamy and Raman (1953) and Endrizzi (1957) have concluded that *S. halepense* is a segmental allopolyploid which arose from a cross between two species closely related cytologically with one parent at least possessing the rhizomatous character.

Garber (1950), from cytotaxanomic studies, believed that there is only one species of *Sorghum* with 20 somatic chromosomes, the other reputed species (Snowden 1936) being only well defined varieties. Garber (1950) divided the *Eu Sorghums* into *S. vulgare* (2n = 20) and *S. halepense* (2n = 40). Quimby and Martin (1954) and Endrizzi (1957) also questioned the justification of specific rank given to some 20 chromosome species and, in addition, Endrizzi queried the specific distinction between *S. almum* and *S. halepense*. If this is so it should be possible to freely transfer desirable characters among cultivated sorghums and grass sorghums. Quimby and Martin (1954) in reviewing inheritance in cultivated sorghums showed that many characters are controlled by relatively few alleles. Hadley (1958) obtained hybrids between grain sorghum and Johnson grass which included highly sterile 30 chromosome and relatively fertile 40 chromosome types. Hybrids between cytoplasmic male-sterile grain sorghum and Johnson grass included male sterile 40 chromosome types. Rhizomes of the 30 chromosome types were vigorous and those of the 40 chromosome types were generally much weaker.

S. almum is predominantly cross pollinated (McWhirter, unpublished data). *S. almum* shows no segregation of *S. halepense* types. Parodi (1946) observed variation in degree of rhizome development, the appearance of inflorescences, the shape and coloration of the spikelets, and the degree of abscission of spikelets at maturity. Hutton (see Table 2) has found variation in cyanogenetic glucoside content but no plants completely free of cyanogenetic glucosides. Considerable variation in height and thickness of culms, width of leaf blades, leafiness, degree of tillering, and persistence, has been observed by the authors. The chief plant breeding objectives are distinctive seed colour and low cyanogenetic glucosides. While a strain with short rhizomes is desirable for ease of eradication in moist regions, a lower rainfall ecotype may show increased persistence with strongly developed rhizomes. In the Argentine, Parodi and Scantamburlo (1954) report the progress made in breeding high yielding *S. almum* strains free of rhizomes. These strains will be suitable for the higher rainfall agricultural areas of the humid pampa.

Tome (1954) crossed *S. almum* with Kaffir grain sorghum and sweet sorghum. He concluded that it is possible to breed perennial sorghums that are not invasive, with sugar containing sap in the stalks and larger caryopses which are not shed at maturity. The self fertility of the progeny of Kaffir grain sorghum x *S. almum* hybrid was extremely high. Endrizzi (1957) crossed *S. almum* with *S. halepense*, Texas Black Hull Kaffir and common Sudan. The *S. almum* x *S. halepense* hybrids were intermediate between the two parents, with a slightly closer resemblance to *S. halepense* than to *S. almum*. Very little heterosis was apparent in the hybrids. While *S. almum* may cross freely with *S. halepense*, crosses with *S. vulgare* varieties will be less frequent.

There are unlimited opportunities for breeding and selecting improved strains of perennial forage sorghums for particular environments. *S. almum* exhibits a wide range of variation which could be readily increased by interspecific hybridization. This strongly contrasts with the lack of variation within strains of many promising sub-tropical and tropical grasses because of apomixis. The plant breeder is unable to produce variation in apomictic pasture species by hybridization.

Conclusions

Through lack of experience with various introduced strains of *S. almum* under Australian conditions, the shortcomings of this species have been incorrectly over-emphasised. The prohibition which has been disregarded by graziers since inception is now considered to be unwarranted. *S. almum* can be safely grazed in all seasons provided simple precautions are observed. The fear that the commercial strains of *S. almum* could become a weed is completely unfounded in areas with less than 30 inch rainfall in Queensland. However, marked inter-strain variation exists in the degree of rhizome development and abscission of spikelets at maturity. Certain strains may be difficult to eradicate in higher rainfall areas. The seed certification of recommended strains of *S. almum* is an immediate necessity to prevent the production of off type strains through interspecific hybridization with *S. halepense*.

Large scale sowing of improved pastures in Queensland has been restricted to date by the high cost of cultivation, high cost of grass seed, and difficulties of establishment. Improved pastures have been developed mainly on land which previously carried dense scrub, such as brigalow, gidyea or rain forest, because the pastures can be cheaply established by sowing seed in the ashes following a burn. It is now economical to plough out native pastures or brigalow suckers and sow down to improved perennial pastures based on *S. almum*. The low price of seed, ease of establishment and high first year production on fallowed land ensure a quick return to cover all costs involved.

S. almum is adapted to 46 million acres of black earths and grey and brown soils of heavy texture in Queensland between the 15 to 30 inch isohyets. These soils are of high natural fertility. However, the success of *S. almum* pastures is dependent on the development of improved sub-tropical and tropical pasture legumes by plant introduction and breeding. The inclusion of these in the mixtures will ensure adequate available nitrogen to maintain the productivity and persistence of *S. almum*. Under these conditions, increases in carrying capacity of the order of the sixfold increase obtained at Moree may be expected over large areas of Queensland without the use of fertilizers.

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Thesis Summary

A Study of Water Use and Dry Matter Production of Lucerne under Irrigation and Natural Rainfall

The aim of these studies was to determine the effect of a number of factors on the water use and the growth of lucerne under irrigation and under natural rainfall conditions. An additional aim was to find out if the growth and water use of lucerne in the second year depended on its previous treatment. An experiment was designed in which there were two main treatments: 1. Soil moisture always maintained as far as possible at field capacity. 2. Under natural rainfall (non-irrigated).

Gypsum blocks and thermistors were installed down to five feet so that the amount of water required to bring back the whole soil

profile to field capacity could be calculated weekly. The dry weight of the lucerne was used as a criterion of growth.

It was found that irrigation water never penetrated below two feet. In practice, the amount of water required to bring back the whole soil profile to field capacity could not be applied every week due to low infiltration rates and quick run off.

Water use was found to be independent of the amount of herbage present and also of dry matter production. During any inter-harvest period, the efficiency of water use increased with time to a peak value, thereafter declining, and was also found to be independent of the amount of water applied. Prescott's relationship of water use to evaporation from a free water surface and to saturation deficit were found to fit the data satisfactorily. The amount of irrigation water applied and the available water stored led to a constant value of Prescott's index ($W = KE_w$ 0.75), regardless of the environmental conditions and age of the lucerne. Penman's estimate of evaporation from an open water surface underestimates the actual evaporation from a free water surface and his "potential transpiration" consistently underestimates the actual water use by irrigated lucerne. Calculations based on Prescott's methods fit the present water use data better than those based on Penman's, and give a more reliable estimate of water use by irrigated lucerne in Adelaide summer conditions.

Dry matter production was shown to be a function of the dry weight of the shoots present at the beginning of the period. The rate of dry matter increase reached a maximum when the dry weight of tops was between 10-15 cwt per acre, and had fallen to zero by 35 cwt/acre. A possible explanation based on the concept of leaf area index is put forward. The growth of lucerne immediately after defoliation is postulated to depend on air and soil temperatures and the number of shoots per crown; once the dry weight of tops reaches 10 cwt/acre the rate of the growth then becomes independent of seasonal conditions and the same final yield is attained.

There was no difference in the efficiency of water use under natural rainfall conditions compared to that under irrigation because a decrease in water use is associated with a decrease in dry matter production. The efficiency of water use increases with the amount of rainfall and a linear relationship was obtained between water use and the amount of available water stored plus rainfall.

Under non-irrigated conditions dry matter production was largely dependent on rainfall and was independent of the amount of available water stored. There was a linear relationship between the amount of water added to the irrigated plots and the amount by which the yield of the non-irrigated plots fell below that of the irrigated plots.

In the second summer, plots which had previously been irrigated were compared with those which had remained under natural conditions, there being no further water applications. There was no significant difference in pF of soil water, moisture content, water use and efficiency of water use in the two series of plots. Although weeds had been completely suppressed in the non-irrigated plots there was no significant difference in the number of lucerne plants per unit area in the two series. Previously irrigated plots always gave higher yields than did the non-irrigated plots and an examination of the soil temperatures in both series of plots showed that the irrigated plots were still colder than the non-irrigated plots at all depths except six inches.

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The Field Determination of Soil Reaction

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A large number of acid-base indicators has been examined to find the best combination for use in a simple colorimetric determination of soil reaction in the field. A solution containing 0.2 per cent. phenol red, 0.12 per cent. bromocresol purple and 0.08 per cent. bromocresol green in water neutralized to pH7 has proved to be the most suitable since it gives a series of bright colours over the whole pH range encountered in soils. A small sample of soil is mixed with this solution to form a paste which is then sprinkled with barium sulphate powder. The soil reaction is then found by comparing the colour developed on the powder with a colour chart. The colours on this chart are based on the colours given by soils with known pH values in 1 : 5 suspensions.

The values obtained by this method agree well with laboratory determinations. An examination of 182 soil samples showed that the field soil reactions had a standard deviation of 0.42 units from the glass electrode values for 1 : 5 soil-water suspensions. The reliability of this technique is therefore adequate for many purposes and it can be widely applied in soil surveys and advisory work.

In 1950 Raupach described an indicator mixture for the rapid determination of soil reaction. This technique has been of much value because of its simplicity and usefulness in the field. He used a mixture of four sulphonphthalein indicators and the colours ranged from yellow with soils at pH4 to dark blue at pH9. These colours were absorbed on a white background of barium sulphate. Generally the colour could be distinguished to the nearest half pH unit and the field estimates usually agreed with laboratory values within the same limits. Raupach (unpublished data) has also suggested a 0.12 per cent. aqueous solution of cresol red as a separate indicator for the

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presence of calcium carbonate in soils. This indicator gives an orange colour at pH8.2 and increasing intensities of light red-purple for pH values above 8.3.

This technique however could be improved by extending its pH range and by increasing the amount of colour change between the various pH values. A large number of indicator mixtures has been examined with this end in view.

There are many limitations which restrict the choice of indicators. They must be stable and readily soluble in water and not absorbed by the soil or changed by reaction with it. Moreover as the pH changes the various acid and alkaline indicator colours must combine to give a well-defined series of bright colours. These restrictions mean that only a few of the many acid-base indicators which are available can be used for soil reaction measurements.

Selection of Indicators

The most obvious way to improve the previous mixture is to introduce an indicator giving more intense colours especially in acid solutions. Methyl red and other members of the amino-azo group were tried first since they are commonly mixed with sulphonphthaleins to produce universal indicators with a complete range of colours. However in acid solutions this group of indicators forms coloured cations which are adsorbed by nearly all soils and consequently acid soils give no colour on the barium sulphate powder unless excessive quantities of these indicators are used.

Hexamethoxy red was also examined because it is red in acid solutions and colourless above pH5 (Kolthoff 1932). But it is not suitable because it is only slightly soluble in water and because the coloured cations which form in acid solutions are strongly adsorbed by soils. Heptamethoxy red behaves similarly. These indicators and the amino-azo group include nearly all the indicators which give red colours in acid solution.

The nitrophenols give satisfactory colours with soils but their yellow alkaline colours are not easily combined with other indicators to give a suitable colour range. Indicators of the phthalein and benzein groups are not sufficiently soluble in water to be useful. The ferric complex of catechol-disulphonic acid (Sen, Berg and West 1957) gives a series of good colour changes from green in acid solution through blue and violet to orange in alkaline solution but, in the more concentrated reagent required for soil testing, these changes are not observed and are replaced by a single sharp colour change from purple to red with soils at about pH5.5. This type of colour change does not combine satisfactorily with other indicators. Some other indicators (e.g. the anthraquinone group) cannot be used because they form complexes with some metal ions in the soil. Only the sulphonphthalein group seems to fulfil all the requirements for reliable soil pH indicators.

Combinations of indicators from this group offer two ranges of colour—from yellow through orange to purple and from yellow through green to purple. The first colour range was not practicable because there are no sulphonphthalein indicators changing from yellow to red near pH4.5 and because orange colours are also given by this group of indicators in very acid media. For the second colour range only bromocresol green of the available indicators changing at lower pH values, gave a good blue colour. Indicators, like bromophenol blue, which have a purple alkaline colour were not satisfactory because of the dull brownish colours produced in the presence of the yellow acid forms of other indicators. In spite of this defect bromocresol purple had to be used because there is no blue substitute for it in the region of pH6.

In indicator mixtures, phenol red was better than cresol red for indicating soils of about pH8.5 because it changes to red rather than purple and its colour change is thus more distinct against the blue background of the other indicators. The best simple combination of indicators that are readily available was found to be bromocresol green, bromocresol purple and phenol red.

The composition of this mixture was varied to find the best range of colours. Increasing

amounts of the indicators changing at higher pH values were necessary because their change has to be visible against the darker background of the lower pH indicators. A solution of 0.08 per cent. bromocresol green, 0.12 per cent. bromocresol purple and 0.2 per cent. phenol red was found to be the most satisfactory. The colours given by this mixture with soils are listed in Table 1. The changes in the range from pH3.5 to 5 are not as great as is desirable and the addition of a small quantity (say 0.04 per cent.) of tetra-bromophenol blue may be an advantage but this indicator was not obtainable. Bromophenol blue and tetraiodophenolsulphonphthalein do not improve the colour in this acid range because they have purplish alkaline colours.

The presence of calcium carbonate is shown by a purplish colour. The orange colour given with extremely acid soils is due to the change of phenol red from yellow to orange at about pH2; the other two indicators change to violet only below pH0. Generally the actual pH of the paste formed by mixing the soil with the small amount of water in the indicator solution, as in the technique outlined below, is about one pH unit below that in the 1 : 5 suspension of the laboratory determinations. The values given in Table 1 are not these paste values but are those that would be given by the soils in a 1 : 5 suspension.

TABLE 1

Colours given by the new indicator mixture with soils of different reactions.

pH of soil in a 1 : 5 suspension in water	Colour of indicator on barium sulphate powder
2	Orange
3	Orange-yellow
4	Yellow
5	Yellow-green
6	Green
7	Greenish-grey
8	Blue-grey
8½	Purplish grey
9	Greyish purple
10	Purple

Preparation of the Indicator Mixture

Weigh out 0.2g of phenol red, 0.12g of bromocresol purple and 0.08 g of bromocresol green, and grind together in a glass or agate mortar with 9 ml of decinormal sodium hydroxide solution till all the solid material has dissolved. Dilute this solution with about 70 ml of water and bring it to pH7.0 using a pH meter. Make up to 100 ml and store in a pyrex or plastic dropping bottle.

Technique for Field Determinations

The method of using this indicator mixture is the same as that originally described by Raupach (1950). Take a small quantity of soil—about half a gram—and mix it on a porcelain spot tile with a few drops of the indicator to give a paste. Dust the paste with barium sulphate powder and compare the colour with a standard colourchart after about three minutes.

Barium Sulphate Powder

The barium sulphate must be free from acid or alkaline impurities. This may be tested by mixing some powder with the indicator; the paste should be a grey-green colour and free from yellow or purple specks. The powder should not be so fine that it forms lumps which absorb the indicator unequally and give uneven colours. On the other hand free-running coarse powders give dull colours and may even fail to mask the soil colour.

None of the commercial products, usually sold for X-ray examinations, that have been tried so far, has been entirely satisfactory. Some were too fine and others were not neutral to the indicator. A sample of ground barytes was found to contain alkaline particles which could not be removed completely even with boiling acid. A satisfactory product may be made if necessary by the following procedure.

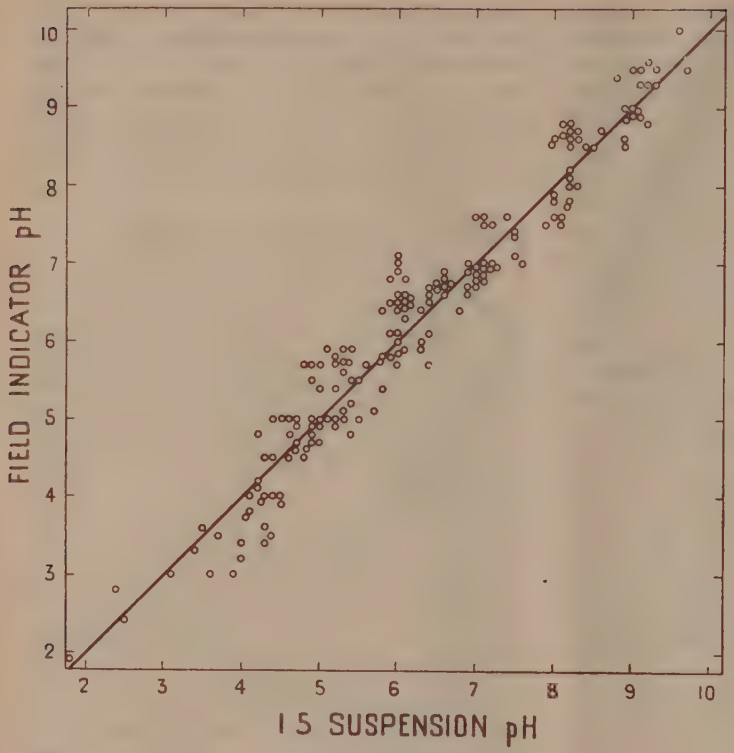

Figure 1—Readings of soil pH obtained by a single observer using the field indicator method, plotted against the 1 : 5 soil water suspension results. The line represents agreement between the two methods.

Prepare one litre each of half molar solutions of barium chloride and of sodium sulphate. Heat about four litres of water to boiling and add 30 ml of concentrated hydrochloric acid. Keep this hot dilute acid stirred continuously and allow the barium and sulphate solutions to run in slowly at equal rates. The addition of the reagents should take an hour or more. When the reaction is complete allow the barium sulphate to settle and draw off the supernatant liquor. Wash the product repeatedly till it is neutral to the indicator then dry in an oven. This product may vary slightly in fineness but it was always superior to all the commercial products which have been tested.

The Colour Chart

For each calibration point on the pH scale about ten soils were chosen whose suspension pH values lay within 0.1 units of the desired value. Equal quantities of these soils were mixed to obtain standards which should give the average colour for soils of that pH value. The colours given by these mixtures were matched, within a few minutes of development, as closely as possible to permanent water colours on heavy weight paper. From these colour chips a standard colour scale was prepared in half-unit intervals from pH2 to pH9.5.

Accuracy of the Technique

The reactions of 182 soil samples were estimated by two observers using the standard colour chart and the values were recorded in 0.1 pH units although this was known to be beyond the capabilities of the method. These values were then compared with the pH values in 1 : 5 suspension which had been recorded previously.

The results fitted the regression line.

$$pH_i = 1.013\ pH_s - 0.041$$

where pH_i is the pH found by the indicator

method and pH_s that in a 1 : 5 suspension in water. The regression coefficient is highly significant. Figure 1 presents the data for one of the observers. Since the regression coefficient does not differ significantly from one the values fit the expected line of unit slope shown in this figure.

An analysis of the results allows an estimation of the errors due to observers alone, due to deviations from the regression line with no observer contribution and for a single estimation as would be made in the field (Table 2).

The results given in Table 2 show that the error of a field determination using the colour chart is the same as the deviation from the 1 : 5 suspension value.

TABLE 2

The standard deviations and fiducial limits of the errors associated with the indicator pH determination. Figures in pH units.

Deviations due to	Standard deviation for a single determination	Degrees of freedom	5% fiducial limits
observers alone	0.21	182	±0.42
differences from regression line with no observer error	0.36	180	±0.72
a single determination using the regression line including observer error*	0.42	181	±0.83

*Because of the highly significant regression line these deviations also represent those of a single determination from the 1 : 5 suspension value.

As expected, the error of matching the colour of the soil paste to that of the chart is less ($P<0.001$) than the error due to the differences between this method and the laboratory determinations on the 1:5 suspension. These differences are due to the varying properties of the soils being examined and the obvious dissimilarities between the two techniques. For example the indicator mixture is more strongly buffered than the aerated distilled water used to prepare the suspensions for electrometric determinations, and a poorly buffered sandy soil will react differently in either case. Again in the presence of gypsum or large amounts of other salts the two methods will not give the same pH values because of the differences in the salt concentration in the aqueous phase and in the times of reaction.

A single determination by the indicator method has a standard deviation of 0.42 pH units. On the average there will be a difference from the 1:5 suspension value which will exceed 0.8 pH units once in every twenty determinations. However the variation of soil pH within an area in the field gives 5 per cent. limits ranging from 0.31 to 1.32 units (Raupach, 1954) so that from the view-point of relative accuracy this method is satisfactory. It therefore provides a simple and reliable way of measuring soil reaction in soil survey and agricultural advisory work.

The Division of Soils, C.S.I.R.O. hopes to produce standard colour charts in the near future for sale at cost to workers who are able to make use of them. If this is possible a note to the effect will appear in this journal.

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Technical Notes

Effects of Fertiliser and Lime Pelleted Seed on Nodulation and Growth of Vetch on the Red Basaltic Soils of the Lismore Region

Past research in the Far North Coast of N.S.W. has led to the development of a fertiliser mixture for use when sod-seeding inoculated legumes in this area (Carter, Crofts and Jenkins 1956; Crofts 1957). This fertiliser, referred to as "Special Mix", is prepared by mixing two cwt molybdenized superphosphate and two cwt ground dolomite with ten lb sodium nitrate and is applied at four cwt per acre. It has given satisfactory nodulation and good subsequent growth of legumes in both experimental plots and commercial sowings. It is however bulky to handle, four cwt of the mixture being required to provide two cwt of superphosphate, and expensive, costing about £4 per acre.

Work with lime pelleted seed by Loneragan, *et al.* (1955) and others suggested that there might be a use for it in this area, particularly with vetches (*Vicia sativa* L.), where annual costs of establishment, using a neutral superphosphate mixture, are relatively high.

Previous work by the author with lime pelleted seed in the glasshouse had shown that vetches and subterranean clover (*Trifolium subterraneum* L.) could be successfully nodulated when sown together with molybdenised superphosphate, if the peat inoculum culture was dusted on after pelleting and just before sowing. This work was not conclusive because conditions for nodulation are much more favourable in pots than in the field. All past field trials with pelleted seed had failed due to unsatisfactory commercial peat cultures.

Preliminary field investigations have been carried out to compare the nodulation and growth of vetches sown under the two systems of establishment.

Experimental

The site of the trial was a paspalum (*Paspalum dilatatum* Poir.) dominant paddock which had never been sown to vetches and had had no fertilisers for many years. The soil type is described by Nicolls, Colwell and Tucker (1953) as the Wollongbar series of the red basaltic soils.

Vetches were sown on June 7, 1957, with six replications of eight different treatments in plots seven feet by forty feet. The treatments are listed in Table 1.

Special mix was applied at four cwt per acre, molybdenised superphosphate at two cwt per acre and muriate of potash at one cwt per acre. The terms *soft* and *hard* refer to two methods of lime pelleting and describe the nature of the pellet. The seed in all treatments except D and E was inoculated, at commercial rates, with a mixture of agar culture (strain S.U. 302) and slurried commercial peat culture. Treatments D and E were inoculated with dry peat culture. Non pelleted seed was sown at 25 lb per acre and pelleted seed at 30 lb per acre. The plots were sown with the University prototype sodseeder, Breakwell and Jenkins (1953).

Results

Nodulation counts were taken on August 15, 1957. Two random samples, each of twenty one vetch plants, were taken per plot. Nodulation was assessed as *crown* if the plants had one or more effective nodules on the taproot, *effective* if they had effective nodules on any part of the root system or *nil* if they did not carry any effective nodules. After nodulation had been assessed the shoots were cut off at the crown, bulked and the dry matter yields of the tops taken.

Yield cuts were taken on October 22, 1957 when the vetches were in full flower. The harvested samples were botanically separated for vetch and dry matter yields determined.

The results are summarised in Table 1.

TABLE 1

Nodulations and yields of the various treatments.

Treatments	Mean % crown nodulation 15/8/57	Mean % effective nodulation 15/8/57	Mean top weight per plot gms. D.M. 15/8/57	Mean final yield cwt. per acre 22/10/57
A. Nil Inoc. + Special Mix	1.6	16.2	3.4	2.6
B. Inoc. + Special Mix.	96.8	100	16.8	10.0
C. Inoc. + Mo. Super.	83.3	100	12.1	6.3
D. Inoc. Lime Pellet (S) + Mo. Super.	90.7	100	13.1	8.4
E. Inoc. Lime Pell. (S) + Special Mix.	98.8	100	16.6	7.3
F. Inoc. + Special Mix + K.	96.0	100	17.0	19.8
G. Inoc. Lime Pell. (H) + Mo. Super.	94.4	100	12.9	5.9
H. Inoc. Lime Pell. (H) + Special Mix.	99.2	100	17.2	10.2
Min. Significant Difference P =0.05	10.59	—	2.68	5.37

S = soft pellets.
H = hard pellets

The results show a marked response to nodulation. There may have been greater treatment differentiation in the *effective* nodulation results if the dry weather had not prevented planting earlier in the season.

Both neutralisation methods, lime pelleting and the use of special mix fertiliser, gave significantly better crown nodulation than the acid molybdenised superphosphate (treatment C).

The three treatments (C, D and G) sown with molybdenised superphosphate had signifiicantly lower top weight yields than the treatments (B, E, F and H) sown with special mix.

The final yield cut results are complicated by the very marked response to potash. Potash was included to find out if it affected nodulation when sown in close contact with the seed. No treatment with molybdenised superphosphate and potash was included so no direct comparison could be made between molybdenised superphosphate and special mix under conditions where potash was not limiting. However, of the treatments receiving no potash, all but one of the special mix treatments yielded significantly higher than the control but only one of the molybdenised superphosphate treatments had a yield significantly higher than the control.

Discussion

Vetches sown with lime pelleted seed and acid molybdenised superphosphate nodulated as well as those sown with the conventional neutralised special mix, but did not produce as much growth.

The increased growth with special mix is possibly due to additional calcium provided by the dolomite. Dolomite in this case contains 22 per cent. calcium oxide and 14 per cent. magnesium oxide both as carbonate. Evidence by Crofts, Pulsford and Jenkins (1955) suggests that the response was due to calcium in the dolomite and not magnesium.

The results with pelleted vetch seed suggest that this technique, although a cheaper form of establishment, cannot be recommended as a replacement for the conventional method using inoculated seed plus special mix.

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Micro Determination of Sulphur in Plant Material

The most commonly used wet methods for the oxidation of sulphur in plant material are time consuming, and may result in incomplete and variable oxidation of the methionine sulphur (Callan and Toennies 1941).

To overcome these difficulties, the combustion method proposed by Schöniger (1955, 1956), and recently used by Lysyj and Zarembo (1958), for determination of sulphur in organic compounds, was investigated and adapted for oxidation of sulphur in plant material. The method has previously been used for pure compounds with fairly high sulphur content and it was necessary to burn only a few milligrams of material to obtain sufficient sulphate for determination. The sulphur content of plant material is much lower and in order to obtain sufficient sulphate for determination it is necessary to burn much larger samples and therefore to use more oxygen. Nevertheless, for sulphur-deficient plant material the amounts of sulphate formed are fairly small and it is necessary to use a micro-method for the final determination of sulphate. In this work the reduction-methylene blue method of Johnson and Nishita (1952) was used.

Procedure

The apparatus consists of a glass-stoppered, litre, Erlenmeyer flask with about 10 cm of platinum wire fused into the internal surface of the glass stopper. The lower end of the wire is drawn into a spiral 1 cm long and 1 cm maximum diameter and bent upwards to prevent the sample falling out during the combustion. When a litre Erlenmeyer flask is used samples of plant material up to 150 mg can be burnt.

Weigh 20-150 mg (usually about 100 mg) of plant material on a piece of filter paper, 2.5 cm square, cut in such a way that a strip of the paper acts as a wick. Fold and place the

filter paper into the platinum spiral. Introduce 10 ml of absorbing solution (prepared by adding 3 drops of 30 per cent. hydrogen peroxide solution to every 10 ml of 0.4N potassium hydroxide solution) into the Erlenmeyer flask and flush the flask for about 30 seconds with oxygen. Ignite the wick and insert the stopper with the burning fuse into the flask (the flask can be closed with a spare stopper until the wick is lit and the modified stopper inserted). As the gases expand during the combustion, the stopper has to be held in position. When the combustion has ceased (i.e. after 40 seconds), shake the flask several times to speed the absorption of gases and after 45 minutes take an aliquot containing 20-70 μg of sulphur for determination. Boil for a few minutes to destroy hydrogen peroxide, acidify with N hydrochloric acid, and evaporate to, or nearly to, dryness to remove nitrate, and determine the sulphate as described by Johnson and Nishita (1952).

After several determinations specks of glassy material accumulate on the platinum wire. These can easily be removed by heating the spiral in a gas flame and plunging into distilled water.

With large samples of plant material there are sometimes specks of carbon left unburned. These have no effect on the recovery of sulphur.

Discussion

Although the reduction-methylene blue method is probably one of the most sensitive methods for determining micro amounts of sulphur, other methods capable of determining amounts as small as 100-150 μg may be used.

The method is specially appropriate for materials of high methionine content such as casein with which wet oxidation procedures can be particularly unreliable (Table 1).

TABLE 1

Determination of Sulphur in Casein.

Method	Number of Determinations	Mean % Sulphur
Steinbergs' (Steinbergs 1953)	6	0.058
Modified Steinbergs'*	3	0.544
Sodium peroxide micro-bomb ashing, methylene blue determination	8	0.692
Proposed method	12	0.693

*Vanadium pentoxide was used as catalyst and sulphur determined by methylene blue method.

TABLE 2

Sulphur content of plant material (dry weight): Comparison of proposed oxidation procedure with that of Steinbergs' (1953).

Plant Material	Steinbergs' Method %	Proposed Method %
Phalaris tuberosa L.	0.10	0.10
Phalaris tuberosa L.	0.08	0.08
Phalaris tuberosa L.	0.03	0.08
Phalaris tuberosa L.	0.07	0.09
Phalaris tuberosa L.	0.13	0.13
Phalaris tuberosa L.	0.17	0.17
Phalaris tuberosa L.	0.41	0.43
Trifolium spp.	0.12	0.14
Bothriochloa ambigua S.T. Blake	0.12*	0.13
Lolium perenne L. + *Trifolium repens* L.	0.28*	0.30
Vulpia spp.	0.13*	0.14
Juncus polyanthemus Buchen	0.10*	0.11

Most determinations made in duplicate.
*Single determinations made only.

The method is specially appropriate for materials of high methionine content such as casein with which wet oxidation procedures can be particularly unreliable (Table 1).

When the proposed method was compared with Steinbergs' method (Steinbergs 1953) over a range of plant materials (Table 2) some of the values obtained with the proposed method were slightly higher and one considerably higher. It is suggested that the lower values obtained by Steinbergs' method are caused by incomplete oxidation of methionine or by losses of volatile sulphur compounds formed before they are oxidised to sulphate. With the proposed method the average recovery of methionine sulphur added to plant material was 100.1 per cent. (28 determinations).

When the proposed procedure was used to determine the sulphur content of a range of plant materials, it was found that duplicate determinations gave a precision of $\pm$ 0.008

per cent. sulphur at the 95 per cent. confidence limit. Statistical analysis showed that only 7.3 per cent. of the variation was caused by errors in sub-sampling and in burning, the remainder being caused by errors in the method of determining the sulphur.

The speed and simplicity with which the samples can be oxidised and prepared for sulphate determination makes the method suitable for serial routine determinations. It may be used for the determination of other elements, such as phosphorus, halogens, and arsenic (Schöniger 1955; Fleischer *et al.* 1958) in plant material.

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Nemagon and Vapam for the Control of Root Knot of Field Tomatoes

Field trials have recently been conducted at Red Cliffs, Victoria, to investigate the effects of Nemagon (1,2-dibromo-3-chloropropane) and Vapam (sodium N methyl dithiocarbamate) on root knot of tomato. In recent years EDB (ethylene dibromide) has been generally used to control root knot in this area, and a 15 per cent. v/v solution of EDB was used as the standard fumigant for these trials.

Plots were established in spring 1955 on an area of sandy loam infested with root knot nematode, *Meloidogyne javanica* (Treub) Chitwood. Tomato plants were spaced three feet apart in rows four feet apart; there were six plants to a plot. Pearson tomatoes were planted in 1955 to build up nematode infestation. The total yield per plot averaged 94.5 lb, and the mean root rating, on a scale from 0-clean to 5-maximum galling, of the plants at the end of the season was 4.76. Fumigation treatments were applied in 1956 and 1957. The experimental area was spray irrigated during the season when necessary.

Methods of Application of Fumigants

EDB was injected into the soil to a depth of eight inches with a hand injector, at one foot spacings. The injector was calibrated to deliver the correct dosage. After treatment the surface of the plot was lightly raked over to close all holes. Nemagon was applied similarly, but because of the low dosage rates the Nemagon was diluted with power kerosene to give an appropriate volume for the hand injector.

For block treatments the plot dose of Vapam was diluted with three or four gallons

of water and sprinkled evenly over the plot from a watering can. Then a two inch hose was used to flood the plot surface. For row treatments, the diluted Vapam was sprinkled into furrows, and allowed to soak in for a few minutes before the furrows were filled with water.

1956-57 Season Trials

In the spring of 1956 the three fumigants were each applied at two levels, combined with two levels of potash fertiliser application. Fumigants were applied about four weeks before planting. The tomato variety planted was "62", a fusarium resistant variety bred at Red Cliffs. Potash treatments had no effect on yield or root knot infestation, but the fumigants showed significant effects (Table 1). Some plots were treated with Stauffer N244 (3 parachlorphenyl 5 methyl rhodanine) at the rate of 3 g/sq. ft. This material was sprinkled on the ground and dug in. It had no effect on plants or nematodes.

1957-58 Season Trials

In spring 1957 two tomato varieties, "62" and Bonny Best were planted in each plot. This combination of fusarium resistant and fusarium susceptible plants was used to investigate the influence of Vapam on fusarium. However the yield figures showed no interaction between variety and treatment, probably indicating that fusarium infection was not severe on any plots. Yields from Bonny Best averaged 6.25 ± 2.5 lb per three plant plot less than the yields of "62" but this could be a varietal difference.

Nemagon and Vapam were applied as row and block treatments. Details of the application rates, mean yields of tomatoes and root ratings are shown in Table 2.

Some plots which had been fumigated and planted in the 1956-7 season were replanted with clean seedlings in 1957. Appreciable effects of Nemagon and EDB fumigation were still evident, but the rates at which the fumigants had been applied did not influence the yields in the second season Table 3).

Some plots which had been fumigated in 1956 were re-treated with the same fumigant at the same rate in 1957. Where either EDB or Nemagon had been used, the mean yield in the 1957-8 season was about 4 lb per plant greater on double treated plots than on plots treated only in 1956. This difference was highly significant. Plots which were treated with Vapam 20 gal/ac for two successive seasons yielded about 3.5 lb/plant more in the second season than plots treated only in the first season, but this difference could not be shown to be significant.

Conclusions

Vapam applied as a block treatment at 80 gal/ac gave good control of root knot and highest yields. Row treatments at the same rates, or block treatments at 40 gal/ac or less, were significantly less effective. On a cost basis Vapam could not compete with Nemagon or EDB.

Nemagon and EDB both controlled root knot effectively at dosages used, though where

TABLE 1

Tomato yields and root ratings 1956-7 season.

	Control	Vapam		Nemagon		EDB	
		10 gal/ac	20 gal/ac	1½ gal/ac	3 gal/ac	20 gal/ac	40 gal/ac
Mean yield lb/ plot of 6 plants	40.5	47.5	68.5	93.75	102.25	109.0	113.5
Figures underlined do not differ significantly.							
Mean root ratings 0-clean 5-maximum	4.75	4.73	4.18	0.1	0.04	0.0	0.0

TABLE 2

Tomato yields and root ratings 1957-8 season.

	Control	V40	Nr1	Vr1	Vr2	Nr2	N2½	N5	V80
Mean yield lbs/plot of 3 plants	13.5	26.0	30.0	31.0	31.5	39.25	45.0	40.25	51.5
Figures underlined do not differ significantly.									
Mean root ratings 0-clean 5-maximum	4.79	3.33	1.04	2.54	1.50	0.29	0.20	0.0	1.66

Treatment code.

Nemagon: Nr1 : ¼ cc/ft in 1 row along plant line (⅝ gal/ac)
Nr2 : ¼ cc/ft in 2 rows beside plants
N2½ : 2½ gal/ac block treatment
N5 : 5 gal/ac block treatment

Vapam: Vr1 : 8 cc/ft in 1 furrow along row (20 gal/ac)
Vr2 : 8 cc/ft in 2 furrows beside plants
V40 : 40 gal/ac block treatment
V80 : 80 gal/ac block treatment

Nemagon was applied in a single row it was significantly less effective than in other applications. Miller (1955) reported that single furrow applications of Nemagon were as effective as double row, and Allen *et al.* (1955) also found the single row application satisfactory. Miller (1955) and Holdeman (1956) found a phytotoxic effect from applications of Nemagon at rates heavier than any used in the present trials. The fumigant controlled nematodes but did not increase yields. Lear and Thomason (1956) reported depression of tomato yields in some cases by Nemagon applied at rates as low as 1.5 gal/ac (block) or 0.6 gal/ac (row). In the present trials block applications of Nemagon at 5 gal/ac did not significantly reduce yields.

The results presented indicate that annual row fumigation will give most effective and economical control of root knot. Applications of about one gallon of Nemagon per acre in a double row treatment should be adequate. EDB was not applied as a row fumigant in these trials, but the good results obtained in the 1956 season suggest it would give similar results to Nemagon. Furthermore it seems likely that dosages of EDB below 20 gal/ac might be equally effective. Most EDB used in

TABLE 3

Yields and ratings of tomatoes in second season after treatment.

	Treatment 1956/57			
	Control	Vapam	Nemagon	EDB
Mean yields 1957-8 lbs/plot of 3 plants	13.5	5.0	27.25	32.5
Figures underlined do not differ significantly.				
Mean root ratings 0-clean, 5-maximum	4.79	4.89	3.18	1.58

commercial practice now contains only 12.5 per cent. by volume ethylene dibromide, and is applied at about 20 gal/ac, probably very effectively.

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The Use of Botulinus Toxin as a poison for Kangaroo (Marloo) Control in W.A.

Over much of the Pastoral region of Western Australia the Red Kangaroo (also called Plains Kangaroo or Marloo)—*Macropus rufa*—is one of the greatest factors preventing regeneration of the natural vegetation and hence the maintenance or improvement of production from pastoral holdings through the practising of deferred grazing. Marloos also compete directly with sheep for the available feed, such competition is at times so severe as to necessitate drastic measures being adopted to control the pest. Because water is a limiting factor in most of this region, and watering points offer a method of concentrating the pests, this medium offers the easiest method of poisoning the marloo.

In the past, strychnine, arsenic and cyanide have been the poisons recommended for use in controlling the marloo, with limited success, e.g. on one property 7,000 were poisoned in a campaign conducted in 1956. Even following such wholesale slaughter the infestation had returned to normal within three months after the cessation of poisoning. Clearly, concerted district wide action is necessary and this will only come when a cheap, effective and easily applied method of destruction is available.

It is considered that the use of Botulinus toxin as a poison for the control of kangaroos is at least worthy of investigation, since it appears to fulfil these requirements.

The Proposal

It is proposed that type C toxin would be used as there already exists a toxoid of this type suitable for the inoculation of stock. There would be no danger of spreading a disease from this work as it is only the toxin (not the living bacteria) which would be used.

Before the toxin can be used under field conditions a determination of the susceptibility of the marloo to the toxin must be made. Also the length of time that the toxin will remain poisonous after it has been placed in the waters found in the station tanks in the area must be determined. These two points can be ascertained under rigidly controlled laboratory conditions.

It is proposed that the toxin would be placed in tanks which are fed by windmills from an underground source, the underground source would not be contaminated. From this reservoir the poisoned water would reticulate to the existing stock troughs. Providing the keeping qualities of the toxin in the waters are sufficiently great it should only be necessary to visit each tank once to poison the entire contents of the tank—from 3,000-10,000 gallons. This should be sufficient volume to poison all marloos drinking from that supply. During the shearing operations before poisoning, all stock on the property would be vaccinated with Type C Toxoid, thus giving them solid immunity which will last for one year and possibly for two years (Oxer 1954)*.

At the conclusion of a fixed period, or when the tank is running low, the addition of quick lime would denature all remaining toxin by raising the pH. At this stage the water containing inactivated toxin would be released and/or the tank refilled.

It seems that this toxin will not harm as many native animals or birds as would any of the orthodox poisons applied in a similar manner for all carrion eaters will probably have a solid natural immunity. The difficulty in preventing losses of native fauna lies in the method of application, and has to be surmounted, no matter what poison is used.

Advantages of the Suggested Procedure

1. The labour required will be reduced by upwards of 80 per cent. for it will not be necessary to muster the paddocks before poisoning, nor to open and close waters each night and morning.

2. It would not be necessary to spend money on capital equipment such as fencing, troughing etc.

3. The efficiency of the poisoning operation i.e. per cent. of marloo population killed will be greatly increased as the existing troughing will be used. Marloos sometimes take up to one or two weeks before drinking freely from strange troughs even when denied water from any other source.

4. Botulinus toxin would be free from any repellent factors. (The L.D.* 100 of 1080 for marloo has been shown to be too high for practical usage of this poison.)

5. The length of the poisoning season will be increased and so a greater area covered. At present the repellent poisons can only be used during periods of excessive heat and a programme of poisoning is always liable to interruption by thunderstorm activity.

6. This poison could be used during drought periods without the handling of otherwise weakened sheep, in mustering, or in interfering with existing water supplies.

7. All toxin remaining in the tank can be positively inactivated by an increase in pH, doing away with the problem of disposal of residues.

8. The operators handling this toxin could be adequately protected by the administration of Toxoid.

9. Preliminary enquiries some time ago showed that the toxin could be prepared and stored in ampoules at very little cost for several million mice doses. Such a cost would probably make this poison cheaper to use than any of the standard repellent poisons.

Disadvantages

It would be necessary for pastoralists to inoculate their stock annually against botulism. The cost of this procedure is approximately one penny per head.

Recent work (Gooding, unpublished data), has indicated that no matter what poison is used to kill large numbers of kangaroos it will be necessary to inoculate all stock on the property against botulism e.g., one station lost 300 sheep from botulism following a poisoning drive in 1956. The poison used was arsenic. Protein starved sheep were poisoned after eating from the carcasses.

*Oxer, D. T. (1940)—*Aust. Vet. J.* **16**, 4-13.

*L.D. 100 = smallest amount of poison to kill 100% of a population.

In a subsequent seven months trial during a normal season when the protein level in the feed remained high, 7.6 per cent. of 500 unvaccinated sheep were unaccounted for at shearing whereas only 3.9 per cent. of the 500 vaccinated ones could not be found.

It may well prove that vaccination is warranted purely as a routine station management procedure.

Human Poisoning

As with all poisons laid out for kangaroo control there is the ever present danger of accidental poisoning of human beings, either white or wandering native. As I see it, there are no more dangers to humans associated with the use of this toxin as a poison for kangaroos than there is with any other poison and when applied with proper precautions these dangers would be minimised.

D. GOODING

Agriculture Protection Board,
Dept. Agriculture,
Perth;
W.A.

Received for publication November 24, 1958.

Book Review

DAIRY HUSBANDRY

By R. Kenney

Thomas Nelson and Sons Ltd., London, Edinburgh, Paris, Melbourne, Toronto and New York, 1957.

"Dairy Husbandry" is a practical handbook on the animal husbandry side of dairy farming, as practised in Britain. Field husbandry, including pasture management, and the provision of other home grown feed stuffs, although often included in dairy husbandry receives scant attention.

R. Kenney, the principal of the Dorset Farm Institute, dutifully opens his book with a discussion of background material—the development of the British dairy industry, based on the whole milk market—the various possible dairy farm systems and the dual and special purpose breeds of dairy cattle. This sets the stage for the main part of the book and points the wide differences between British and Australian conditions. Thus the Australian reader is prepared to find that the practices advocated by the writer require modification in detail and even in principle before they can be applied in the Australian environment.

Two further chapters give plans and details of housing, bails and yards, and dairy herd improvement is discussed though no definite breeding, selection and culling plan is put forward.

In the latter half the book gets at last to dairy cattle husbandry, dealing in turn with calf rearing, young stock, feeding the milking cow, calving and factors affecting quantity and quality of milk production, bull management and a brief description of the main diseases.

In this, the author, always practical, generally clear and easy to read, does not neglect mention of the theory underlying the various practices. One reaches the conclusion that these were the chapters for which the book was written and that the author caught something of the spirit of the British dairy husbandry man who has a true admiration for his cattle. This last conclusion is, like the book, enhanced by the numerous fine quality photographs.

Appendices include short tables listing dry matter, fibre, protein equivalent and starch equivalent contents of most common feeding stuffs.

A list of references is given at the end of each chapter, thus greatly increasing the value of the book to anyone wishing to know more of British farm practice.

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SERVING INDUSTRY . . .
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Talks

The Whole Farm Approach to Agricultural Advisory Work

Dr. A. R. Callaghan, then Director of S.A. Department of Agriculture in an address to South Australian Branch.

Farming for the most part in Australia is not only a complex business but also a way of life that must take into account personal skills and preferences. Its success depends on the integration of technical information with factors peculiar to a particular farm and farmer.

The first advisers in Australia were general practitioners but over the years advisory work has been developed through subject matter specialists, giving advice in their own fields. As a result, we have, to a large extent, lost perspective of the whole farm concept. There is a need to regain the merits of the older approach which has been effectively developed in the advisory services of U.S.A. and Great Britain.

The ultimate aim of advisory work is to increase food production for home consumption and the export market. Greatest value will only come from such a service if it is used to its fullest extent.

In the U.K. and the U.S.A. budgeting is used extensively in advisory work. With large numbers of similar farm units concentrated in one area, application of this procedure, compared with Australia, is relatively easy. In Australia units are scattered, complete farm records are few and only since the last war has exploitation begun to give way to stabilisation and intensification. Farmers, in general, are opposed to accountants and economists and rely on rough mental budgeting to assess new farm practices. Advisory work should attempt to encourage formal budgeting and planning of the whole farm, possibly using the principle of the N.Z. farmers' clubs where a small group of farmers employ an economic consultant. There is one such club at Bombala in N.S.W. and other groups differently organised are operating in W.A.

The S.A. Department of Agriculture recognises that effective extension work requires the integration of P (the persons, i.e. adviser and farmer), I (the technical information) and M (the method).

It is proposed to use economic specialists to backstop District Advisers and to develop the whole farm approach to advisory work with a team of agricultural, soils and livestock officers at the Jamestown regional office. Much detail has still to be worked out. There will be difficult problems to overcome both within the Department and with farmers. As seen in the S.A. Department of Agriculture it is one of the important challenges of our time.

The People and Agriculture of Cyprus

Mr. R. H. Kuchel, Senior Biologist and Oenologist at Roseworthy, in an address to the South Australian Branch.

Mr. Kuchel spent 13 months in Cyprus as a Vine Industry Consultant for the Cyprus Government.

Cyprus, which is only 100 miles from the Holy Land, has had a chequered history during which many races and religions have left their mark. Persians, Romans, Turks, Venetians and British have all had a hand in its development, but it has never been under the control of the Greeks. The present internal strife is continuing to hamper its development. Cyprus became a British colony in 1925.

It is the third largest island in the Mediterranean—3,586 square miles with a population of 510,000. Mountain ranges (3,000′) occur along the N.E. Peninsula and in the centre of the island (Mt. Trodos, 6,000′).

The climate is an extreme Mediterranean type having 5-6 months of the summer without rain. The rainfall varies from 14″ at Nicosia and 17½″ at Limassol to as high as 30″ in the mountains which are covered with undeveloped forests.

Fifteen per cent of the cultivated area is irrigated and most of the water for this comes from the diversion of spate floods

The soils are alkaline, low in organic matter and contain as much as 30 per cent lime.

Wheat and barley are the main crops of the plains while the 2 milion carob trees ("Black Gold of Cyprus") on the seaward slopes give an export of 38,000 tons of beans. There are also 2 million olive trees which are poor by our standards.

The most important changes in the last 10 years have been the development of export markets in citrus, melons and table grapes. Their early ripening gives them an advantage on the U.K. market.

Meat and dairy production is mainly from goats and long-tailed sheep. These are tended by shepherds as there are no fences.

Land ownership is very unwieldy. Farms are small (about 15 acres), and often consist of 10 plots widely separated from each other as a result of the dowry system.

Small demonstration plots are run by the Department of Agriculture near villages, but E.O.K.A. frequently destroys them as soon as they are in production.

There are 70,000 acres under vines yielding 75,000 tons of grapes per year. The wineries can only handle about a third of the grapes in their fresh state and the remainder are dried, as raisins, or turned into crude spirit. Practically all the wine comes from the two varieties "Mavro" and "Xinesteri" which can tolerate poor, limestone soils and rough prunings.

A feature of this wine is its very high tannin content.

Many of the grapes are processed by traditional methods on the growers' properties. Wine is made in earthenware jars and spirit is produced in small 20-50 gallon home stills.

The vine and wine industries are heavily subsidised, and it is important for these industries that Cyprus remains in the British Commonwealth.

The future development of viticulture is hampered by many problems, most important of which are the wineries' inability to handle production, the plantings of vines in irrigated areas to the detriment of the farmers in the poor highland vineyards, the lack of co-ordinated efforts between wineries and vine-growers and the ill-feeling in the country.

What Lies Ahead for the Young Graduate

Presidential address by J. D. McFarlane to N.S.W. Branch of A.I.A.S., Feb. 27, 1959.

Mr. McFarlane said he chose to speak on this subject because he believed it to be the one which should be of greatest concern to the Institute at present, and for at least the next few years.

Before considering prospects of satisfactory employment for graduates he suggested we should spend a little time thinking about some aspects of agricultural development in Australia, in order that later discussions be against the right background.

Referring to selected shire statistics showing changes in sown pasture acreages, sheep numbers, and numbers of holdings carrying sheep Mr. McFarlane emphasised that:

There is an increasing number of landholders for extension officers to visit,

More people are getting started in sheep farming and undoubtedly they would benefit from guidance in technical and managerial matters,

Sheep and wool production is becoming more intensive and complex,

More capital, machinery and skills are required and there is more scope and need for attention to management.

Undoubtedly, expansion of sheep and wool production from improved pastures is currently the most important development in our rural industries, if not in the whole of our national development. If our profession is to make anything like its potential contribution to development we must get down to the farm and help with the changes involved.

The next most important current and future development is the expansion of irrigation farming. The growing importance of farm irrigation schemes is illustrated by recent increases in applications for irrigation licences in N.S.W.:

	Fresh Licences	*Renewals*	*Total*
1955/6	836	865	1701
1956/7	950	894	1844
1957/8	2322	1038	3360

Also, there will soon be great increases possible in irrigation from water distributed from major public works. This year the first 300,000 acre feet of water comes from the Snowy Mountains project; ultimately this project will provide 1.5 million acre feet for irrigation in N.S.W.

The Keepit Dam is nearing completion and the Burrendong Dam is expected to provide for 300 farms.

The first challenge of this projected expansion of irrigation based on public works is what sort of farming is to be encouraged. This is an important issue but it seems to be receiving very little attention.

The other challenge of this irrigation expansion is similar to that presented by the sheep and wool industry in improved pasture areas: to provide science services to a growing number of people

involved in more highly capitalised and complex farming.

Thirdly, Mr. McFarlane said we should consider the agricultural expansion required in Australia to provide home consumption and export income requirements of a growing population. Some estimates by The Bureau of Agricultural Economics of production requirements for a population of 14.1 m. in 1976 are as follows:

Product	*Increase required from base period (1952/3-1955/6) to 1976 per annum*	*Actual increase p.a. 1946/50-1956/7*
Beef & Veal	2.4%	3.2%
Mutton	2.1%	0.8%
Lamb	2.1%	—1.2%
Cereals	2.0%	—2.5%
Potatoes	2.0%	—1.0%
Wool	2.9%	5.0%

Nobody will dispute that technical and management advice to farmers can, and will have to, play an important part in achieving the progress desired.

Fourthly, Mr. McFarlane believes we must consider the role of our profession against the background of world food supplies for a very large and rapidly increasing population. Of all people, we in Australia should keep certain facts in our minds:
The world population, at present 2,700 million is increasing at the rate of about 40 million annually,
Of this population about two thirds are seriously undernourished; of these not more than 1 in 100 ever has a good meal. In fact, only about 1/6th of the population are well fed by our standards,
It is widely held that "the world cannot endure in peace with half living in privation and half in luxury."

Fifthly, he referred to the problem of instability in agricultural production. This, he said, calls for greater attention to fodder conservation, supplementary irrigation, drought feeding techniques, the use of lucerne in dry land pastures, and so on.

Although we probably all agree that agricultural science has served Australia well in recent years Mr. McFarlane said this does not mean that all is as it should be in the profession or that we have set a course to be followed.

Although the numbers of agricultural scientists have built up significantly in the last 8-10 years we are only now at the stage of being able to look forward to having the numerical strength necessary to make real progress in meeting the research and extension needs of our rural industries.

During the last ten years the research sector of agricultural science has been built up in a very healthy manner. The increasing numbers of total *graduate staff* in three Divisions of C.S.I.R.O., viz.; Plant Industry, Soils, and Animal Health and Production, serve as an index of this development:

1949 At 30th June	146
1951 At 30th June	180
1953 At 30th June	221
1955 At 30th June	258
1957 At 30th June	284
1958 At 30th June	315

Likewise, there have been notable increases in the flow of graduates to university and industry positions. Development has been sound in these directions and promises to continue.

By contrast, Mr. McFarlane pointed out, there has not been such sustained development in State services. This is very important, not only because of the essential nature of the services—extension, education and conservation—but because State departments are major employers of agricultural scientists, and will remain so.

The distribution of funds from the recently formed wool and wheat research funds seems, at present, unlikely to provide a stimulus to Department of Agriculture staff recruitment. The Wool Research Committee made the following allocations during 1957/58.

C.S.I.R.O.	£1,560,000
Universities in N.S.W.	70,352
N.S.W. Dept. of Agriculture	1,228

During 1958 the Wheat Industry Research Committee made the following grants:

C.S.I.R.O.	£69,500
Universities in N.S.W.	52,565
N.S.W. Dept. of Agriculture	13,300

The following numbers of graduate staff in selected sections of the N.S.W. Department of Agriculture are in contrast to the above figures indicating research expansion:

	Dec. 31, 1950	*Dec.* 31, 1955	*Dec.* 31, 1956
Plant Industry	29	35	41
Horticulture	6	9	10
*Dairying	0	0	0
*Sheep and Wool	0	0	0

(*Source: N.S.W. Public Service List, of which* 1956 *is the last published.*)

*It is known that graduates listed in other sections; e.g., Hawkesbury College and Glenfield Veterinary Research Station are in effect dairy and sheep and wool research officers, but as they number only 2 or 3 in each case they do not really change the picture.

The report of a N.S.W. Branch sub-committee set up to study certain aspects of the supply of

and demand for agricultural graduates revealed the following balance sheet for the period 1954-7:

Agric. Sci. Graduates	*Dept. Agric.*	*Dept. Educ.*	*Soil Conservation Service*
New appointments	46	3	11
Resignations	39	5	15
Retirements	2	0	0
Deaths	0	1	0
Nett gain or loss	+5	—3	—4

When considering these figures we must keep in mind that there are 21 experiment farms and stations (including two College farms) operated by either the Department of Agriculture or the Soil Conservation Service. These properties form a very large proportion of the field research facilities available to agricultural scientists in this State.

To appreciate the full significance of these figures we should also keep in mind the paucity of extension officers: the ratio of rural holdings in N.S.W. to district agronomists is something like 2,300:1. The ratio of sheep properties to sheep and wool officers is of the order of 3000:1. (If we consider graduate extension officers alone the ratios become something like 6-7,000:1 and 38,000:1-2, respectively.)

Translation of research findings into farm practice must surely be slow in these circumstances.

Mr. McFarlane claimed that this is the crux of the matter as far as development of scientific agriculture in this State is concerned. There is a pressing need for a large number of extension opportunities —with conditions of employment appropriate to such important professional work—mainly in the Dept. of Agriculture but also in industry. In due course there is likely to be increased interest on the part of farmers and graziers in the formation of extension groups, each served by an extension officer whose salary is paid from the contributions of group members. This group activity is reported to be succeeding well in New Zealand and Europe, and where it has been initiated in Australia, so it seems that it should be fostered in Australia by agricultural scientists and by primary producers and their organisations. Just as primary producers acknowledge the value of contributing to research funds they are in some cases now acknowledging that they can profit from investing in extension.

Extension work, unfortunately, has not enjoyed the same prestige as agricultural research, and this has, of course, been reflected in working conditions and salaries. Although only relatively few graduates have been attracted to extension positions such employment could, without difficulty, be transformed into a most absorbing field of work, demanding a high standard of professional training and efficiency and deserving of good status within the profession and in the community. As the managerial problems of the farmer are accentuated by increasing biological, chemical and engineering complexity, and increased investment, the call for, and appreciation of, advisory services will be immeasurably greater. In fact, many farmers and graziers now frankly admit that they need much more help with technical matters. After paying research levies for a few years they will probably be more vocal in this regard—they will look for some flow of results from the research they have financed. Perhaps they might press for their industry research funds to be expanded to become research and extension funds.

This Institute has a duty to do all it can to promote an expansion of graduate employment in extension services. This duty stems from the importance of extension work in our agricultural development and from the role played by the Institute in publicising careers in agriculture.

Mr. McFarlane suggested that members of N.S.W. Branch, particularly Committee members, should consider two lines of action which might be effective in the promotion of extension work to a higher level in our agriculture.

Formation of an extension section within the Institute (at least within the Branch). There are many people interested in extension—in State Departments, banks, industry, universities, and on the land. There are many matters deserving the attention of such a group; e.g., extension methods, training of extension workers, liaison between research and extension workers, the extension needs of various industries and districts, and the role of extension workers in defining research problems.

Establishing an extension sub-committee in N.S.W. to study and report on some of the aspects just mentioned.

Finally, he urged that careful thought be given to the contents of the report "Agricultural Scientists in Australia" and that, in particular, we should ponder over the graduates who, even during a period of shortage of graduates, have not found satisfying employment for reasons such as

—inadequate equipment or funds for their work
—excessive time spent on menial manual jobs or administrative chores
—poor salaries
—lack of leadership

—frustration during the critical period when fresh from University, full of enthusiasm and up-to-date in knowledge and ideas.

—when added to some, or all, of the above, various smaller issues can cause discontent; e.g., frustrating travel arrangements, or even the lack of petty cash.

Rectifying causes of discontent is in some cases a matter for individuals in responsible positions, in other cases for Departments or the Public Service Board. Mr. McFarlane expressed the hope that the survey report will stimulate the numerous people involved to initiate many improvements in the employment opportunities and conditions for agricultural scientists.

Fertilisers and Farmers

Presidential Address by W. B. C. Mackie to Victorian Branch, April 17, 1959.

The great development in Australian agriculture since World War II is illustrated by the increase in the acreage sown to improved pastures, from 10 million acres in 1945/46 to 32.6 million acres in 1956/57. At the same time, there has been a gradual intensification of farming systems on many properties.

Today, in Victoria, which has some 23 million acres of occupied land available in the better rainfall districts for pasture improvement, 14 to 15 million acres have received fertiliser as a top-dressing to pasture or with crops. Livestock numbers have increased steadily, and crop yields have risen. A trend towards ley-farming, on both wheat farms and grazing properties, has been a significant development.

These changes in the pattern and scale of farming have resulted in a big increase in fertiliser consumption, and in a great dependence of farmers on the fertiliser industry to supply the many kinds of fertilisers to meet their respective needs. In 1954 it was estimated, by Strong and Saxon, of the Bureau of Agricultural Economics, that one-third of the total earnings of Australian rural industries was largely dependent upon superphosphate. The welfare of agriculture and the fertiliser industry is, therefore, intimately bound together. We might adopt the biological concept of symbiosis to describe this relationship. However, the industry must do more than just supply the fertiliser requirements of the farming community, it must help to bring forward new opportunities for progress in farming, by co-operation with research and extension organisations—all the time seeking new avenues for improving the prosperity of agriculture, to which its own livelihood is tied.

In studies of farmers' attitudes to fertiliser usage, it appears that most farmers look to fertilisers to lift output, and they recognise the opportunity for capital gain in their properties. However, they do not appear to look consciously upon fertiliser usage as a means of lowering unit production costs or for increasing net income. This situation reflects a lack of sufficient guidance in the economic aspects of fertiliser usage. Fertilisers normally enjoy a certain allocation from farm income, but they do not hold a priority commensurate with the economic opportunities they provide.

The farmer's expectations of the fertiliser industry may be summarised thus:—

(1) To supply economic, high quality fertilisers suitable for the requirements of his crops and pastures.

TABLE 1

Trends in fertiliser usage

Australia

Year	Quantity of Fertiliser			Area Fertilised With All Fertilisers		
	Crop 1000 tons	Pasture 1000 tons	Total 1000 tons	Crop m. acres	Pasture m. acres	Total m. acres
			All Fertilisers			
1935	625	195	820	14.99	3.85	18.94
1938	810	383	1,193	15.62	5.66	21.28
			Super Only			
1943-44	247	159	406	8.99	4.42	13.41
1947-48	582	474	1,056	15.58	9.07	24.65
1951-52	587	817	1,404	13.94	15.55	29.49
1956-57	773	1,232	2,005	13.35	22.31	35.66

(2) To give him advice on the most profitable means of using fertilisers.
(3) To pass on the benefits of scientific progress in the form of new and improved products which make farming a more successful and profitable business.
(4) A sympathetic interest in the farmer's welfare.
(5) An ability to meet the wishes of all farmers practically simultaneously.

The industry is keenly aware of these expectations of the farmer, and is doing all it can to meet his wishes.

In general, manufacturers are providing good quality fertilisers and service, within the limits of the price the farmer is prepared to pay. A close liaison is effected with research and development in local and overseas institutions. Wherever practicable, improved manufacturing techniques are introduced here. Recent developments have been in the improved physical condition of fertilisers, ammoniation of super, and bulk handling from factory to farm, as well as the introduction of suitable insecticide, trace element, and complete fertilisers. The industry is assisted in these developments by the research organisations of the Commonwealth and State Governments, and of the Universities.

TABLE 2

Prices of superphosphate per metric ton of P_2O_5 at various centres.

Country	Percentage W.S. P_2O_5	Price per metric ton W.S. P_2O_5 in Bulk ex Works September 1958 (£ sterling)
Australia (Melbourne)	20.5	36.85
New Zealand	20.0	41.26
France	18.0	49.94
Japan	16.5	58.32 (delivered)
South Africa	19.0	50.69 (trade only) 62.37 (bags)
Spain	17.5	43.10
Morocco	17.5	48.57 (plus tax 5.26%)
United Kingdom (less subsidy of £6/15/- on price of £13/1/6 ex Works)	18.0	71.49 34.59

The development of high analysis fertilisers is still distant. Nitrogen fertilisers in Australia are, at the present, too expensive to be economically attractive to most farmers. The ratio of unit cost of N to P_2O_5 in Australia is about 3½:1, compared with 1½:1 in the highly industrialised countries, but Australia has about the world's cheapest unsubsidised superphosphate. Nevertheless, the time will come when it will be economically possible to use nitrogen to a much greater degree and, in the meantime, we should determine the best opportunities, and methods, for more intensive fertiliser usage.

Since 1922, the Victorian fertiliser industry has employed advisory officers to assist farmers obtain the best economic use of fertilisers. It has been the aim of the industry to employ graduates in agricultural science for this purpose, and now there are 8 to 9 graduates, and at least an equal number of diplomates, working in this field throughout Australia.

Because he tends to identify his interest with that of the farmer, the advisory officer is a most valuable link between the industry and the farmer. The result is the farmer's goodwill and friendliness for the industry, in return for its interest in his welfare. Besides giving advice on the use of fertilisers, the adviser is frequently called on to assist the farmer make decisions affecting the management of the farm as a whole. Fertiliser practices, over a period of time, can completely alter the nature of a farm's enterprises, and necessitate big adjustments in labour and capital. So far, the industry's advisers have assisted the farmer to solve these economic problems, but for the future they look hopefully to the specialists in farm management.

For many years the industry's advisory services have provided one of the most important extension channels carrying the results of research to the farmer. Although government extension services mainly discharge this function today, there is still the important job of liaison between the industry nad the many research and advisory services of other organisations. The industry enjoys a high measure of confidence and co-operation from the State Departments of Agriculture and other authorities, and it is important that this harmony be maintained.

These duties, required of the advisory officers of the fertiliser industry, necessitate the employment of suitably qualified agricultural scientists. It is the training and experience of these men on which the industry depends for its close working partnership with the farmer.

News Items

Cobalt Bullets for Cattle

Details of a new cobalt bullet suitable for dosing cattle have recently been released by C.S.I.R.O.

The new bullet is similar in composition to the SI-RO-CO cobalt bullet for sheep but is larger and heavier. The new formula is based on research at the Nicholas Institute for Medical and Veterinary Research in consultation with C.S.I.R.O.

Field trials have convincingly shown that it is the best means yet devised for countering cobalt deficiency which occurs in many cattle raising districts of South Australia, Western Australia, Victoria and Tasmania.

A big and highly valuable market for this cattle cobalt bullet is expected to develop especially in the United States and other overseas countries where there are large areas of cattle country known to be cobalt deficient and where a real problem has existed for many years. It will be recalled that experiments by C.S.I.R.O. led to the invention of a cobalt bullet for sheep and to its release to sheep-owners in September, 1957.

Trials involving about 700 head of cattle carried out in South Australia, Victoria and Tasmania over 8 months, clearly indicated that the cobalt bullet for cattle is as effective as the sheep bullet is for sheep. In the trials, treated cattle have shown a marked gain in weight and improvement in health over untreated cattle. Dairy cattle have shown improved milk production where cobalt deficiency was a limiting factor.

The cobalt bullet is placed in the gullet with a special "gun" or plastic tube and swallowed into the paunch where it provides a continuous well-regulated release of essential cobalt, all day, every day.

Why Cobalt is Necessary

The function of cobalt is to ensure the production of essential vitamin B12 by the bacteria in the paunch of cattle. The vitamin is essential for normal growth and maintenance of life and also plays a part in blood formation. Young growing cattle and lactating cows require continually available vitamin B12—and hence cobalt—and it is these animals that are particularly susceptible to deficiencies.

Symptoms in Cattle

Symptoms of cobalt deficiency in cattle develop more slowly and are less specific than those in sheep. Calves especially are susceptible. Young animals are weak when born and few survive more than a week if their mothers are acutely deficient. There is a decrease in appetite in adult animals, loss of condition, anaemia and decrease in production. The coat of cobalt deficient cattle is harsh and dry.

Effects in cattle may be less obvious than in sheep, but the total economic loss due to cobalt not being continually available to cattle is perhaps equally great. Treatment and prevention of cobalt deficiency in cattle had been difficult for various reasons.

Cattle are often run in areas where (a) top-dressing is not regularly practised; (b) weekly drenching is difficult and time consuming; (c) irregular intake by cattle makes the supply of cobalt by licks an inefficient method. Some animals ignore licks.

Definite diagnosis of cobalt deficiency has never been simple with cattle. Symptoms are not specific enough to allow easy identification of the disease—and soil and pasture analysis is tedious and unreliable. By developing knowledge of known cobalt deficient areas, regions of acute deficiency have been mapped in South Australia, Western Australia, Victoria and Tasmania, but many marginal deficient areas remain unidentified.

Cobalt Bullets—Sheep Need to be Re-Dosed

Sheep grazing potentially toxic phalaris pastures should be re-dosed with cobalt bullets every autumn, C.S.I.R.O. warned recently.

Results of recent C.S.I.R.O. tests show that it is dangerous to rely on the previous year's bullets to protect flocks against phalaris staggers. Most outbreaks of phalaris staggers occur during May and June, after sheep have grazed the young phalaris shoots emerging after autumn rains. Cobalt bullets given as soon as the season breaks will prevent the disease.

Annual dosings are needed because up to a quarter of the flock may shed their bullets during the year. Also a deposit of calcium phosphate makes some bullets ineffective and others may become inactive without this visible coating.

Methods of overcoming these problems are being studied by officers of the C.S.I.R.O. Division of Biochemistry and General Nutrition. It is hoped that as a result a new type of bullet will eventually be produced which will remain effective for a much longer time.

Promotion Talks in Three Countries

Wool promotion throughout the world has been discussed recently at conferences on three overseas continents. Representatives of the Australian Wool Bureau attended.

The conferences were held during May and June in the United Kingdom, U.S.A. and Uruguay. Australia's delegates were the Chairman of the Wool Bureau (Mr. W. A. Gunn) and Mr. D. R. Hawkes of South Australia.

Mr. Gunn attended the annual meetings of the Wool Bureau Inc., New York—an affiliate of the Australian Wool Bureau—in New York on May 5. Mr. Hawkes attended the meeting as an observer and later the two men represented Australia at the annual meetings of the Executive of the International Wool Publicity and Research Fund in London on May 14.

The woolgrowers of Australia, together with the woolgrowers of New Zealand and South Africa, finance wool use promotion in 14 countries through these two bodies.

On June 9 they attended a world conference on wool promotion and research in Montevideo, at the invitation of the Uruguayan Wool Board.

It was the first wool promotion conference yet held with representatives of the wool producers of South America.

Seven Hills Poultry Research Station

The Seven Hills Poultry Research Station has benefited by £20,000 from Commonwealth Loan and Egg Marketing Board Funds. Six thousand pounds will go towards a new laboratory for physiological and genetical work; pens for nutrition experiments will cost £7,000. Most of the remainder will be spent on research into the genetics of broilers and the study of egg quality.

Aid to Extension Workers

The problem of extension workers of keeping up-to-date with results of research, has now been eased by the publication of "Liaison Notes" by C.S.I.R.O. in conjunction with the State Departments of Agriculture. The publication will be for issue to extension workers and not to farmers. There are two series—a general one and a sheep series. These notes aim at providing extension workers with information arising from some aspect of current research, in both plant and animal problems. It is hoped that the information will be applied to current industry practice and used as a basis for extension articles or in planning field experiments. Several issues have already been prepared.

Sydney University Farm at Camden

Professor Robinson reports that construction of the Meat Laboratory at the Camden farm is virtually completed and that the first course in meat, for Agriculture students, has been initiated. The Dairy Physiology Laboratory, which will be under the supervision of Dr. Whittlestone, will also be finished soon.

Combatting Seepage Losses

Major General R. W. Eather, Executive Director of the Water Research Foundation of Australia, recently gave details of a dam sealing experiment being carried out at Pearce's Creek in Northern New South Wales. The experiment could lead to a means of saving the frightful seepage waste of water in areas where other methods of dam sealing are not applicable.

The success of this venture in sealing research would be a boon to dairy farmers, banana growers and others who rely on a continuous supply of water.

The experiment was carried out by the Department of Agriculture in conjunction with the Water Research Foundation of Australia and consisted of laying an impervious blanket of bentonite clay on the walls and floor of the dam. This clay, which is highly colloidal, swells 10 to 15 times its normal dry volume when wetted, and fills the small voids in porous ground through which seepage takes place.

A close study of results of this experiment may indicate that further research is required before the technique can be perfected. The Foundation is exceedingly interested in research into all methods which can save water on the farm.

New C.S.I.R.O. Wool Dyeing Process

A new method of dyeing wool has been developed by C.S.I.R.O. Wool Textile Laboratories. The dis-

covery was made by Dr. B. S. Harrap of the C.S.I.R.O. Division of Protein Chemistry.

Dr. Harrap described the process to members of the Society of Dyers and Colourists of Australia at a meeting of the Society's Victorian Section in Melbourne last March.

The method depends on treating wool top or loose wool with a cold solution of dyestuff in an organic solvent for a minute or two. Dyeing time is reduced still further by first wetting the wool with the solvent.

In normal dyeing of wool, the wool goods must be boiled in an acid solution, usually for more than an hour.

In the new process no heating is required in the dyeing. However, the solvent must be recovered for re-use, and this aspect is now being examined.

A good deal of work still remains before it can be applied commercially.

Fresh Water from the Sea

In the Channel Islands the Guernsey Water Board have made an historic decision by ordering the first sea water evaporating and distilling plant for commercial operation in a country with an adequate rainfall. The economy of Guernsey depends upon sufficient fresh water supplies for its fruit and flower industries, and the new plant will ensure these supplies even if drought conditions prevail locally. The installation will provide half a million gallons of fresh water daily from the sea, and in making use of the Multi-flash method the Guernsey authorities have found that it will prove cheaper than building reservoirs and catchment areas to collect rain. This is because the design of the plant allows very high rates of fresh water production per unit of heat input for much lower capital cost than was previously possible.

This new method of producing fresh water is an important fundamental development, even for countries with an ample rainfall, as in addition to considerably reducing capital outlay, it can also be designed to combine the economic production of electricity and "soft" water for industry as well as domestic supplies.

Rockefeller Grant to C.S.I.R.O.

C.S.I.R.O. Laboratories at Canberra have been given $100,000 by the Rockefeller Foundation for special items of equipment for the Divisions of Plant Industry and Entomology.

This is the second large grant that C.S.I.R.O. has received from the Rockefeller Foundation in recent years. Four years ago, the Rockefeller Foundation provided $250,000 towards the cost of the Giant Radio Telescope which will soon be constructed for the C.S.I.R.O. Division of Radiophysics at Parkes, New South Wales.

The C.S.I.R.O. Division of Plant Industry will use its portion of the grant to get three major items of equipment: a mass spectrometer, radioactive source equipment for inducting mutations, and an ultracentrifuge.

These will be used to extend the Division's work on the study of Rhizobia. It is hoped to develop suitable types of microorganisms for problem regions and to improve the effectiveness of those already available.

The C.S.I.R.O. Division of Entomology will purchase an infrared spectrometer, an ultra centrifuge, and electrophysiological equipment. This will enable the Division to intensify its work on insect physiology and biochemistry.

The Division already has an impressive record of successes in developing methods for controlling insect pests, including cattle tick, sheep blowfly, buffalo fly, pests of stored wheat, red-legged earthmite, lucerne flea, and the argentine ant.

The Rockefeller Foundation was established by Mr. John D. Rockefeller in 1913. Its purpose was "to promote the well-being of mankind throughout the world".

The Foundation makes grants to medical education and public health, biological and medical research, agriculture and the humanities.

The assets of the Foundation have a current market value of more than $500,000,000 and a sum of about $40,000,000 is given away each year.

Since its inception 46 years ago, the Foundation has distributed more than $600,000,000. Grants are made to institutions in many countries of the world.

Agricultural Chair at University of Tasmania

A development of wide agricultural interest is the recent announcement that a Chair of Agriculture is to be established at the University of Tasmania. This follows the recommendations of the Murray Report viz.:

"We believe the proposal for a Faculty of Agriculture justifies every support. Tasmania is essentially an agricultural state, with certain characteristics both of environment and structure of the agricultural industries peculiar to it. Moreover it can be claimed that agriculture is beyond question a technology which would best serve the principal industrial need of the State, and it would strengthen community interest in and support for the University."

Applications for the position of Professor closed recently and when appointed the new Professor will assist the University Council in the organisation of the course and other matters.

It is expected that undergraduate teaching in second year will commence in 1961.

Second Victorian Refresher School

In furtherance of its policy of conducting Refresher Schools at 2 yearly intervals the Victorian Branch is planning a Refresher school in Animal Production to be held from August 31 to September 3 this year.

As was the case with the 1957 school in Plant Sciences the aim of the school will be to present recent developments in the sciences underlying animal growth and production. In addition some time will be given to management techniques and economics.

Although the programme was not finally available at the time of going to press, the following outline of proposed subjects will indicate the scope of the school—

Reproductive Physiology — General principles, reproductive physiology of sheep and of cattle.

Growth and Lactation—Growth of skeleton and muscle, follicular development and wool growth, lactation.

Genetics and Animal Breeding—General review, selection for wool production, time of mating, genetic improvement of beef cattle and of dairy cattle, artificial insemination.

Nutrition—Feeding the Australian grazing animal, mineral metabolism in ruminants, vitamins and additives in animal feeding, principles of ruminant nutrition, principles of non-ruminant nutrition, problems of feeding the pregnant animal.

Management—Intensive management of (a) sheep properties, (b) irrigated dairy farms, (c) beef cattle properties.

Economics—Economic structure of the Australian Animal Industry, future of the Australian animal industry.

Each speaker will be an authority in his own field and will be able to indicate the most important research findings of recent times in his own particular subject.

The school will be held at the School of Horticulture, Burnley Gardens, Melbourne. There will be 5 or 6 sessions on each of the four days for which the school will run. Full details will be sent to all Branch secretaries.

W.A. Department Moves – Phase Two

The second of the main office and laboratory building for the West Australian Department of Agriculture is practically completed and is now almost fully occupied. Those who have moved into this block are the Wheat and Sheep Division (including the Sheep & Wool, and Cereal Products Sections), the Horticultural Division, the North West Branch, the Entomological, and Seed Certification and Weeds Sections of the Biological Services Division and the departmental library.

In the recently announced Reclassifications of the W.A. Public Service, there was one major change within the Department of Agriculture. This was the creation of the Biological Services Division, incorporationg the Plant Pathology, Entomology and Seed Certification and Weeds Sections. The Government Plant Pathologist, Mr. W. P. Cass Smith has been appointed the Superintendent of the new Division.

Second Farmer-Scientist Joint Conference

The second joint conference was held in the members Pavilion of the Claremont Showground on February 3rd, 4th and 5th. The conference was again organised jointly by the Farmers Union of W.A. and the W.A. Branch of the A.I.A.S.

The total attendance was approximately 300 and of these 36 were A.I.A.S. members including 4 far-

mer members. Of the total present, 137 had also attended the 1958 conference. *Mr. M. M. Wallace*, the President of the A.I.A.S. was elected Chairman of the Conference which was officially opened by the Premier, *Mr. A. R. G. Hawke.*

For this conference, a variation was the use of the discussion group technique, which gave a greater number of people the opportunity to express their views and comments on the various papers presented.

On the evening of the second day about 120 persons attended a social meeting which included a buffet dinner.

The following papers were presented at the Conference:—

"Rainmaking".—Mr. E. R. Smith—Principal Research Officer. C.S.I.R.O.

"Seasonal Growth of Wool and Meat"—Dr. L. C. Snook—Animal Nutrition Officer, W.A. Dept. of Agric.

"Conservation Farming for Profit"—Mr. S. McIntosh—Farmer, Northam.

"Our Salt Land Problem"—Mr. S. T. Smith—Senior Soil Research Officer. W.A. Dept. of Agriculture.

"Getting Salt Land into Production"—Mr. B. Parker—Farmer, Kulin.

"Water Demineralization"—Mr. J. Lewis—Engineer, Public Works Department.

"Water Runoff and its Control"—Mr. B. Marsh—Soil Conservation Adviser. W.A. Dept. of Agric.

"Water in the Future Development of Australia"—Dr. S. H. Bastow—Chief Executive Officer, C.S.I.R.O.

"Plant Growth and Water Relations"—Mr. A. W. Humphries—Research Officer, C.S.I.R.O.

"Fattening Livestock on Irrigated Pastures"—Mr. F. Craig—Farmer, Dardanup.

"Water Conservation and Irrigation"—Mr. W. Frost—Farmer, Kendenup.

"Irrigation Practice in W.A."—Mr. H. K. Gibsone—Officer in Charge Irrigation, W.A. Department of Agriculture.

"Irrigated Pastures and their Management"—Mr. F. E. Ryan—Agrostologist, W.A. Dept. of Agriculture.

New Headquarters for Bureau of Sugar Experiment Stations

On Thursday, December 4 last, the new Administrative Headquarters in Brisbane of the B.S.E.S. were opened officially by Queensland's Premier, the Hon. G. F. R. Nicklin. The Bureau, a 51 year old organisation, was until 1951 a Government sub-department under the Ministry of Agriculture and Stock whose premises it shared. In that year an amendment to "The Sugar Experiment Stations Act" removed the Bureau from Public Service control and since that time, it has been administered by a Board representing the Government, the cane-growers, and the raw-sugar millers. The industry now finds some 96 per cent. of the funds required for the Bureau's operation and the growing demands for increased services and the need for more office and laboratory space influenced the Board to seek these new premises.

The reinforced concrete and brick building has two floors and a basement, and provision for a further floor if required in the future. The upper floor has been devoted to administrative offices, the library, a conference room, and a staff amenities room while the ground floor contains the laboratories (soils, pathological, etc.) and associated workrooms. Both floors are fully air-conditioned. The basement which is extensive contains several work and store rooms, a loading dock, and facilities for off-street parking.

On the roof of the building is the Bureau's official quarantine glass-house in which all imported canes will be grown for a year before release.

A.N.Z.–A.A.S. 1959
Programme – Section K

SUNDAY, 23rd AUGUST

Full day excursion to Mundaring and York to study forestry, soils and agriculture of the region. There are extensive pine plantations at Mundaring and interesting soil sequences on the dissectional and depositional surfaces of the Avon River at York. Officers from the Department of Agriculture, Forests Department, C.S.I.R.O. and the University will be present.

MONDAY, 24th AUGUST

9.30 a.m.—Enrolment.

11.15 a.m.—FORESTRY SESSION:

"Ash Bed Effects in Western Australian Forest Soils", *A. B. Hatch*, (Forests Department, Dwellingup, W.A.)

"Controlled Burning in Western Australian Forest Practice", *A. C. Harris* and *W. R. Wallace*, (Forests Department, Perth).

"Forest Mapping from Air Photographs", *P. J. McNamara* (Forests Department, Perth).

2.15 p.m.—Concurrent Sessions:

(a) JOINT SYMPOSIUM (Sections L and K): "Toxic Effects of Pasture Plants".

"Facial Eczema", *N. T. Clare* (Department of Agriculture, Ruakura, N.Z.)

"Lupinosis in Sheep", *Dr. H. W. Bennetts*, (Department of Animal Health, Perth).

"Lupin Alkaloids", *Dr. W. D. Crow* (C.S.I.R.O. Division of Industrial Chemistry, Melbourne).

"Some Aspects of Pyrrolizidine Poisoning", *Dr. C. C. Culvenor*, (C.S.I.R.O. Division of Industrial Chemistry, Melbourne.)

"Bloat in Ruminants", *Dr. A. T. Johns*, (D.S.I.R., Division of Plant Chemistry, N.Z.)

(b) SOILS SESSION

"Effects of Crops, Pastures and Bare Fallow on a Queensland Black Earth" —*Professor L. H. J. Teakle*, (University of Queensland).

"Structural Changes in Soils of the Wheatbelt of Western Australia—*T. C. Stoneman*, (Department of Agriculture, W.A.)

"A New Theory on the Nature of Soil Humus"—*Dr. R. J. Swaby*, (C.S.I.R.O. Division of Soils, Adelaide).

"Soils of the Merredin Area, W.A."—*E. Bettenay*, (C.S.I.R.O., Division of Soils, W.A.)

TUESDAY, 25th AUGUST

9.15 a.m.—DARWIN SYMPOSIUM—All Biological Sections.

2.15 p.m.—Concurrent Sessions:

(a) SYMPOSIUM — "Phosphorus in Soils and Plants."

"Phosphate Usage in Western Australia", *G. H. Burvill*, (Department of Agriculture, Perth).

"Factors Influencing the Loss of Phosphate Fertilizers from Sandy Soils"—*P. G. Ozanne* (C.S.I.R.O., Division of Plant Industry, Perth).

"The Phosphate Balance Sheets of Three Soil Types from the Coastal Plain, W.A."—*F. Hingston*, (C.S.I.R.O. Division of Soils, Perth).

(b) JOINT SESSION (Sections L and K): "Animal Husbandry".

"The Water Consumption of Lactating Dairy Cows at Pasture under Temperate Conditions in New Zealand". *Professor I. L. Campbell* and *R. Munford* (Massey Agricultural College, New Zealand).

"Husbandry Problems Associated with the Production of Milk of Substandard Quality"—*K. Needham* (Department of Agriculture, Perth).

"The Suitability of Indian Game Males for the Production of Broiler Chickens as Compared with other Commercial Breeds of Poultry"—*R. K. Ryan*, (Department of Animal Husbandry, University of Sydney).

"Supplements for Sheep During Drought in Pastoral Areas"—*Dr. L. C. Snook*, (Department of Animal Health Laboratories, Nedlands).

WEDNESDAY, 26th AUGUST

9.15 a.m.—PRESIDENTIAL ADDRESS: *C. S. Christian*, B.Sc. Agric., M.S. (Chief of Division of Land Research and Regional Survey, C.S.I.R.O., Canberra.

"The Future Revolution in Agriculture in Northern Australia".

11.15 a.m.—SYMPOSIUM: "Pasture Establishment on Light Lands."

"Microbiological Factors Controlling Pasture Establishment in W.A."—*W. P. Cass Smith*, (Department of Agriculture, Perth).

"Pasture Establishment on Light Lands in W.A."—*L. Shier* (Department of Agriculture, Perth).

"Calcium and pH in Legume Establishment"—*Dr. J. F. Lonergan*, (C.S.I.R.O. Division of Plant Industry, Canberra).

2.15 p.m.—PRESIDENTIAL RECEPTION.

THURSDAY, 27th AUGUST

9.15 a.m.—SYMPOSIUM—"Planned Land Use in the Higher Rainfall Areas".

"Strategy of Phosphorus Usage and the Policy of Maximum Production"—*J. K. Taylor* (C.S.I.R.O., Division of Soils, Adelaide).

"Principles Governing Land Use in Higher Rainfall Areas"—*A. C. Harris,* (Department of Forests, Perth).

"Planning Land Use in Higher Rainfall Areas of W.A."—*Dr. H. P. Schapper, D. W. Treloar, M. Parker* (Institute of Agriculture, University of Western Australia).

"The Western Coastal Plain—A New Agricultural Region?" *A. W. Humphries* and *Dr. R. C. Rossiter,* (C.S.I.R.O., Division of Plant Industry, Western Australia).

"Some Possibilities of Land Use in the Higher Rainfall Areas of Northern Australia," *C. S. Christian,* (C.S.I.R.O., Division of Land Research and Regional Survey, Canberra).

2.15 p.m.—SYMPOSIUM: "Conservation of Soil Resources".

"Bridging the Difference Between Present and Potential Land Use", *D. V. Walters,* (C.S.I.R.O., Agricultural Research Liaison Section, Canberra).

"Full Soil Conservation is Only Achieved by Best Land Use," *R. G. Downes,* (Soil Conservation Authority of Victoria).

"A Relationship of Broadscale Ecological Surveys to Detailed Planning of Land Use," *R. G. Downes, F. R. Gibbons, R. G. Thomas,* (Soil Conservation Authority of Victoria).

"The Leaching of Some Plant Nutrients and its Relationship to the Improvement and Maintenance of Soil Fertility"—*Dr. D. P. Drover* and *F. J. Roberts,* (Institute of Agriculture, University of Western Australia).

FRIDAY, 28th AUGUST

9.30 a.m.—SYMPOSIUM: (Sections M and K): "The Use and Abuse of Natural Grazings in Semi Arid Regions".

"The Influence of Grazing and Burning of Native Pastures at Katherine, N.T."—*Dr. M. J. T. Norman,* (C.S.I.R.O., Division of Land Research and Regional Survey, Canberra).

"The Reaction of Spinifex Pastures to Grazing"—*H. Suijdendorp,* (Department of Agriculture of Western Australia, Carnarvon).

"Grazing Effects on the Shrub and Tree Growth of Arid and Semi Arid Regions of W.A."—*G. E. Brockway,* (Forests Department, Perth).

"The Economics of Fodder Conservation: Some Examples for Central Queensland"—*J. Dillon* and *R. Mauldon,* (University of W.A.).

2.15 p.m.—Concurrent Sessions:

(a) SYMPOSIUM—(Sections H and K): "Design of Agricultural Machinery".

"What the Farmer Wants"—*O. H. Heinrich,* Horwood Bagshaw Limited, Adelaide.

"Towed and Driven Wheels in Agricultural Equipment"—*Dr. J. Phillips,* Department of Mechanical Engineering, University of W.A.

"Design of Agricultural Machinery"—*G. H. Vasey,* University of Melbourne.

(b) FORESTRY SESSION:

"Selection for Breeding of Monterey Pine"—*J. M. Fielding,* (Forestry and Timber Bureau, Canberra).

"Observations on the Development of Jarrah Seedlings"—*A. C. Van Noort,* (Forests Department, Perth).

"Thinning in Cut-over Jarrah Stands"—*W. R. Wallace* and *F. D. Podger,* (Forests Department, Perth).

"Fertiliser Responses in Pinus Pinaster Plantations"—*E. R. Hopkins,* (Forests Department, Perth).

"Soil Phosphate Uptake by Pinus Pinaster", *A. B. Hatch,* (Forests Department, Perth).

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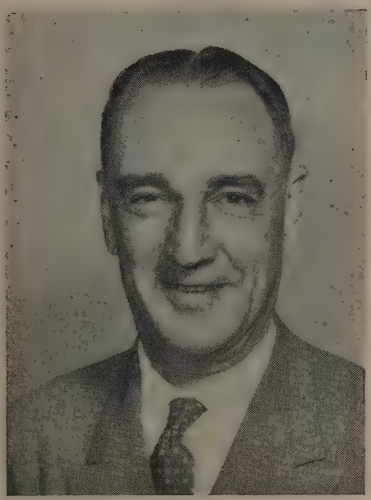


Mr. A. G. Strickland, Director of the South Australian Department of Agriculture, has been elected President of the Australian Institute of Agricultural Science for 1959.

Mr. Strickland graduated in agricultural science from the University of Melbourne in 1927 and joined the Victorian Department of Agriculture as a Horticultural Research Officer.

He joined the South Australian Department of Agriculture in 1934 as Chief Horticulturist and was appointed Chief of the Division of Plant Industry in 1954 and Director of Agriculture in May this year.

In 1939 Mr. Strickland visited U.K., Europe and U.S.A. for both the Federal and South Australian Governments to report on fruit trade and horticultural matters, and in the same year was Australia's representative at the 18th International Agricultural Conference at Dresden, Germany.

Other responsible positions held by Mr. Strickland include a member of the Plantings and Sub-divisional Advisory Committee of War Service Land Settlement (Irrigation), Chairman of the Irrigation Development Committee, Deputy Chairman of the Dried Fruits Board, Chairman of the Dried Fruits Processing Committee and also Chairman of the South Australian Potato Board.

Mr. Strickland has also been responsible for the successful control of fruit fly in South Australia since its initial outbreak in 1947.

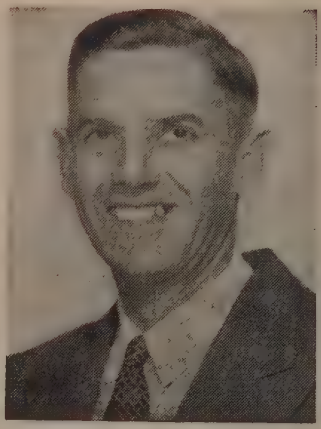
He was awarded a C.B.E. in 1951 in recognition of his expert knowledge and advice not only to Government but also to orchardists, particularly in the establishment of new irrigation settlements.

Mr. Strickland was President of the South Australian Branch of the Institute in 1947-8.

The Australian Medal of Agricultural Science

Award for 1959 to Messrs. C. G. Hughes and D. R. L. Steindl

C. G. HUGHES



D. R. L. STEINDL

The Australian Medal of Agricultural Science for 1959 has been awarded jointly to Messrs. C. G. Hughes and D. R. L. Steindl for their work on sugar cane diseases particularly that on the virus disease ratoon stunting. Both men are Senior Pathologists with the Bureau of Sugar Experiment Stations, Brisbane. Both received the degree of Bachelor of Agricultural Science with Honours from the University of Sydney; Hughes in 1934 and Steindl in 1935. Both have been pathologists with the Bureau of Sugar Experimental stations since their graduation.

Basis for Joint Award

The research into sugar-cane diseases by Messrs. Hughes and Steindl during the past decade, i.e. 1949-58, has been highlighted by the discovery of ratoon stunting disease in sugar cane, its transmissibility, alternative hosts, and its identification as an important factor in the world-wide decline of sugar-cane varieties, together with the elucidation of economic methods for field control.

The searching investigations by Hughes and Steindl, coupled with visits by them to other sugar-producing countries of the world together with reciprocal visits to Queensland by leading overseas pathologists, established that ratoon stunting disease was of international significance.

The discovery of the disease and its identification by somewhat indefinite internal symptoms has been widely accorded and acknowledged as a real contribution to the study of all externally symptomless diseases. The disease was first established as a mechanically transmissible disease in the Mackay district and by 1952 it had been recorded in all the major cane areas of Queensland. Within a few years ratoon stunting disease was uncovered in practically all cane-growing countries.

Prior to this work the gradual decline in yields of leading cane varieties in many countries had been regarded as a serious threat to efficient sugar production. Plant breeders and geneticists were unable to determine a mechanism for it in a vegetatively propagated crop particularly in the absence of obvious disease symptoms. It has now been shown that, in many instances, infection by ratoon stunting disease has been a major factor in varietal decline.

Control measures originally evolved as early as 1949 by Hughes and Steindl include heat treatment of diseased cane setts either in hot-air ovens or in

hot water, field sanitation in the sterilisation of knives and the use of disease-free planting material. These methods have stood the test of time and have been eminently successful in countries as far apart as Queensland and Louisiana, Taiwan and Mauritius.

Ratoon stunting disease and its control has brought a new awareness as to the importance of symptomless diseases in cane breeding and selection work and in testing for resistance to other diseases. It is of direct interest to all agriculturalists handling vegetatively propagated crops.

It is difficult to estimate, accurately, the annual losses caused by the disease but in one district of Queensland the seasonal losses exceeded 125,000 tons valued at £500,000. Aggregate losses throughout the State and in other countries, before the adoption of control measures would be assessed as many millions of pounds.

Dr. E. V. Abbott, Division of Sugar Plant Investigations, United States Department of Agriculture, gave an authoritative evaluation of the disease by writing (1953—Sugar Bulletin):—

"The announcement from Queensland, Australia, several years ago of the identification of a hitherto unrecognised growth retarding virus disease of sugar cane which had no readily recognised symptoms constituted the most challenging development in sugarcane pathology in many years."

The challenge of ratoon stunting disease transcended the mere academic investigation of a select problem. Through persistent endeavours in the laboratory, glasshouse and field experimentation, Hughes and Steindl carried the ratoon stunting researches to their logical conclusion, i.e. control of the disease at a commercial level. Time, aided by a vigorous field programme, should record the eradication of this disease from the State of Queensland, as has been the case with such other diseases of sugar cane as downy mildew and gummosis.

Both Hughes and Steindl have contributed important papers dealing with cane pathology to the Congress of the International Society of Sugar Cane Technologists; they are invitational authors of various sections of a text book on sugar cane diseases now in preparation. This publication is sponsored by the I.S.S.C.T.

Hughes is a co-editor of this text and he was also Chairman of the Pathology section for the I.S.S.C.T. Congress held in Hawaii during May, 1959, a position he also held at the Congress in 1950 together with that of Editor of the 1950 Proceedings. In 1951, he was the pathologist member of a two-man, B.S.E.S. expedition which, for the first time, collected varieties of sugar cane and wild canes in the New Guinea highlands. In 1955, he visited laboratories in Europe and America in connection with ratoon stunting disease and other cane pathology investigations. Hughes has been an active member of the Queensland Branch of the Institute being State sub-editor from 1944-48 and Branch President during 1950. To his credit, the investigations into pineapple disease of sugar cane setts and the establishment of mercurial control measures against this disease are also worthy of mention.

Steindl, apart from his role in the discovery of ratoon stunting disease, also uncovered and elucidated two previously unrecorded diseases of sugar cane, namely *Sclerophthora* disease and bacterial mottle. The latter is a bacterial disease caused by an organism in Dowson's *Pectobacterium* group. As early as 1939-40, he conducted experiments with *Rhizobium* strains into the nodulation of cowpea species and made available to farmers, through the B.S.E.S. a supply of effective strains of *Rhizobium* for field inoculations. Steindl was also responsible for the design and implementation of the inspection technique as carried out by the Cane Pest and Disease Control Boards, which were constituted by the 1938 Amendment Act of the Sugar Experiment Stations Act, 1900-1958.

R. J. NOBLE

Few members of the Institute have contributed to the progress of Agriculture in New South Wales as much as Robert Jackson Noble, C.B.E., B.Sc. Agr., M.Sc., Ph.D., who retired on May 17 after 46 years' service with the N.S.W. Department of Agriculture. For the past nineteen years Dr. Noble has been Under Secretary and Director and Permanent Head of the Department. Rare ability, courtesy, dignity and sound judgment characterised him as an administrator and his wide interests carried his influence far beyond New South Wales when he negotiated at interstate, Commonwealth and international levels.

R. J. Noble was educated at Sydney High School and the University of Sydney. He graduated B.Sc. Agr. with First Class Honours and the University Medal in 1915. Immediately on graduation he enlisted and for four years, 1915-1919, was on active service with Australian Imperial Forces in Egypt and France. After the Armistice, Sgt. Noble was appointed lecturer in Agriculture at the Agricultural Training Depot, Sutton Veny, England, pending demobilisation.

On his return to Sydney in 1920, R. J. Noble was appointed to the Biological Branch of the Department of Agriculture as Assistant Biologist studying cereal diseases. In 1921 he was awarded the first Sir Benjamin Fuller post-graduate travelling scholarship and continued his research on cereal diseases at the University of Minnesota, U.S.A. He was awarded the Master of Science degree in 1922 and the following year the degree of Doctor of Philosophy. His doctorate thesis was entitled "Studies on the parasitism of *Urocystis tritici* Koern., the organism causing Flag Smut of Wheat". While in the United States he represented Australia at the 1921 International Conference of Cereal Pathologists in Minnesota and was appointed Collaborator, Cereal Smut Investigations, United States Department of Agriculture, during 1921-23.

Dr. Noble returned to Australia in 1923 and received the appointment of Principal Assistant Biologist. In 1927 he was appointed Chief Biologist, a post he held until 1940. In this period he soundly laid the foundations of the plant disease and dairy and soil bacteriology service of the State, carried on his own research and by wise counsel influenced policy and organisation within the Department as a whole.

Noble displayed wide interest in Scientific and related Societies. He is a member of the Linnean Society of New South Wales and also the Royal Society of New South Wales. He served on the Council of the Royal Society from 1927-39, was Honorary Secretary and Editor of Proceedings from 1929-1934, and was elected President in 1934. He was a foundation member of the Australian Institute of Agricultural Science, President, N.S.W. Branch 1936, Vice-President 1937, and member of the Publications Committee, 1937-1940. He has been a Fellow, Royal Institute of Public Administration, since 1940 and member of the N.S.W. Council since 1952. He has been a Fellow of the Australian & New Zealand Association for Advancement of Science since 1940.

Noble's counsel has been always valued highly and he has served on numerous committees and been appointed to many positions of trust.

In 1945 Dr. Noble led the Australian Commonwealth delegation to the inaugural meeting of the United Nations Food and Agriculture Organisation at Quebec, Canada. In 1957 he attended as a member of the Australian delegation the Ninth Session of the F.A.O. Conference in Rome.

Dr. Noble has been the recipient of many honours including in 1951, the University of Minnesota's Outstanding Achievement Award, Medal and Citation "in recognition of noted professional achievement as an internationally celebrated plant pathologist and administrator." In 1957 he was awarded the C.B.E. by the Queen in recognition of his contributions to agriculture.

Immediately on his appointment as Permanent Head in 1940, Dr. Noble applied himself to building a better Department of Agriculture. His proposals for its reorganisation on a divisional basis, with appropriate delegation of responsibility and authority, received Cabinet and Public Service Board approval and were implemented in the year of his appointment. He conducted his Department with a loose rein, believing firmly that example was better than directive as a goad to progress.

He had clear vision of the way this highly technical and important Department should go and his patient tolerance of those, high or low, who attempted to obstruct or interfere with his administration will be long remembered. He has left a Department with an organisation of which he can remain justly proud and has left behind many friends who wish him a long, happy nad productive period of retirement.

C. J. MAGEE

Personal Notes

Australian Capital Territory

Mr. E. J. Johnston has left Canberra to take up the position of Assistant Direction of Agriculture with the Northern Territory Administration in Darwin. He will assist Mr. W. M. Curteis, the Branch Director.

Mr. R. A. Sherwin who, at the present time, is Agricultural Attache with the Australian Embassy in Washington, led the Australian delegation to the Eleventh World Poultry Science Congress at Mexico City. During this conference he arranged for the Twelfth Congress to be held in Australia in 1962. This will be the first time that this meeting will be held in the Southern Hemisphere.

Mr. D. H. McKay, Acting Director of the Bureau of Agricultural Economics, paid a visit to Rome to the F.A.O. Commodity Meetings.

Mr. W. D. Hardy has returned to Canberra from being Australian Trade Commissioner in San Francisco and has already shown his interest in Institute affairs by accepting appointment to the Branch Committee.

Mr. G. A. Stewart and *Mr. W. Arndt* of C.S.I.R.O., Division of Land Research and Regional Survey, visited a number of islands off Arnhem Land on which aboriginal mission stations are operating. They are reporting to the Northern Territory Administration on the potential for land use on these islands.

Mr. R. M. Moore left for a five month overseas tour during which he will attend the International Symposium on Agronomy at Rehovot, Israel. In addition he will study the flora of the Mediterranean coastline and examine in detail the ecology of plants that have been introduced to Australia from these regions. He will return via North America to attend the International Botanical Congress in Montreal.

After spending twelve months at Alice Springs, *Mr. R. O. Slatyer* of the C.S.I.R.O. Division of Land Research and Regional Survey has returned to Canberra where, apart from his climatological work, he is busy erecting a house and preparing to lead a Symposium on Climatology in Pakistan.

Mr. C. W. E. Moore of C.S.I.R.O.'s Division of Plant Industry has returned to Australia after spending three months at the Department of Botany at the State College of Washington, U.S.A.

New South Wales

Mr. Fred Gruen, who was a special Economics Research Officer in the Division of Economics and Marketing N.S.W. Department, has resigned to take up a new post as Senior Research Fellow, Department of Economics at the Australian National University, Canberra.

Professor N. H. White has been appointed Australian Representative of the Sub-committee for International Plant Pathology—a committee of the American Phytopathological Society.

Professor T. J. Robinson is on a 3 months world tour, with the prime objects of attending the World Congress on Fertility and Sterility at Amsterdam and the World Dairy Congress in London; he returns via the U.S.A.

Mr. A. J. McIntyre, N.S.W. Branch President and Chief Rural Liaison Officer of the Commonwealth Bank, has recently completed an extensive tour of agricultural research projects in Victoria and N.S.W., supported by the bank. He visited Wagga, the M.I.A., Tatura, Kerang, Swan Hill and Merbein with the Rural Credits Development Fund Sub-committee of the bank.

Miss Susanne Kemeny has relinquished her post as Experimental Officer with the C.S.I.R.O. Sheep Biology Laboratory at Prospect in order to spend a busman's holiday in the U.K.; she left Australia in May and will be away for two years.

Victoria

Mr. W. B. Miller, Superintendent of Agriculture, left for an overseas trip on May 9. He will be away approximately 6 months and will visit U.S.A., Canada and the United Kingdom.

Mr. D. B. Godwin has taken up an appointment as an Agricultural Missionary in North-Western Australia.

Mr. B. F. McKeon, Senior Technical Executive Officer of the Department of Agriculture left recently for a 4 months trip abroad.

Mr. M. B. Beck has joined Nitrogen Fertilisers Pty. Ltd. as a Technical Officer.

Miss G. Easton, Seeds Analyst, and *Mr. R. L. Twentyman,* Senior Agrostologist, of the Department of Agriculture, attended the Australian Seed Testing Conference, held in Sydney during April.

There are now three generations of Wards in the Institute: Joe, former Horticultural Superintendent in the Victorian Department, is an emeritus member in the Victorian Branch; his son, Keighley, is a Horticulturist in the Queensland Department, and is a member of the Queensland Branch, and now Keighley's son, David, has just joined the Queensland Branch. He graduated last year, and is an agronomist in the Queensland Department of Agriculture and Stock.

Queensland

Mr. J. Hughes has left the Plant Nutrition Section of the Department of Agriculture and Stock to take up a Lectureship in Agricultural Chemistry in the Department of Agriculture at the University at St. Lucia.

Dr. W. Owen McCarthy has been appointed Senior Lecturer in Agricultural Economics in the University of Queensland and will take up duties on October 1. He is a New Zealander and obtained his Ph.D. from Iowa.

Dr. P. J. Skerman conducted 16 Indian visitors on a 10 day tour of the sheep districts of Queensland during April. This was arranged under the Colombo Plan as part of a 6 month nation-wide visit in which contacts are being made with the State Departments of Agriculture, C.S.I.R.O., the Universities, and other organisations.

Mr. R. C. Colbran returned in April to the Entomology Branch of the Department of Agriculture and Stock from the Department of Nematology of the University of California where he spent a year working on the systematics of nematodes and looking into developments in control techniques.

Mr. R. Milford has been awarded a C.S.I.R.O. Studentship for two years to be taken up at the Grasslands Research Station at Hurley, England. He and his family are due to leave in August. *Mr. L. A. Edye* will be transferred from Brisbane during Mr. Milford's absence.

South Australia

Dr. A. R. Callaghan, Director of the S.A. Department of Agriculture for 9 years, has been appointed Commercial Counsellor of the Australian Embassy in Washington, D.C.—U.S.A. The appointment is for 5 years. His duties will be concerned with the promotion of Australian primary and secondary products in the U.S.A.. He will also advise on U.S. trade practices, particularly for those commodities which Australia exports. Dr. Callaghan relinquished his duties at the Department of Agriculture on March 9, and left for America on May 6, 1959.

A doctorate of Science was conferred on *D. S. Riceman* for his thesis entitled "Zinc and Copper Deficiency in plants".

Mr. A. R. McKeown resigned recently from his position of Senior Lecturer in Agriculture at Roseworthy College. He has returned to Western Australia to take up a Research appointment at the

Institute of Agriculture where he will work with Dr. J. Millington.

Mr. W. F. Nankivell is to be congratulated on becoming the Member for Albert in the House of Assembly in the State Parliament.

Mr. C. B. Wells who recently received his M.Ag.Sc. degree, has been awarded a Sir George Murray Scholarship and leaves for Rothamstead in late July. He will work under Muir and Bloomfield on the form and movement of secondary carbonate in soils.

Mr. B. G. Williams who has recently taken an honours degree in Soil Science, is now working in New Guinea.

Mr. M. B. Spurling, Senior Horticultural Research Officer with the South Australian Department of Agriculture, has been awarded a South East Asia Treaty Organisation Research Fellowship. Mr. Spurling will spend 4½ months in Indonesia, Malaya, Burma, and Thailand. He will collect seed of native species of citrus having potential value for variety and stock improvement work in Australia. At the same time he will report on the horticultural problems of the areas visited, particularly Thailand where he will be located for 2 months.

Mr. R. F. Seamark, who was recently awarded the Barr-Smith Travelling Scholarship, is being employed in the Agricultural Chemistry Department for some time before undertaking studies at Cambridge.

Tasmania

George Kolar, until recently conducting research in the Chemistry Department at the University of Tasmania, has taken up a position as research officer at the Australian Wine Research Institute in Adelaide.

Leon Smith has left the position of Agronomist with the Tasmanian Department of Agriculture to work at the I.C.I. Merrindale Biological Research Station, Croydon, Victoria.

Graeme Inglis, formerly Agricultural Economist with the Tasmanian Department of Agriculture, has transferred to the State Treasury. His resignation from the Institute has been regretfully accepted.

Dr. John Loveday, of the Soils Division, C.S.I.R.O., who was engaged in surveys of soils and land use in Tasmania before his recent study at Rothamstead, has transferred to the C.S.I.R.O. Irrigation Research Station at Griffith, N.S.W.

Western Australia

Dr. R. C. Rossiter, of Plant Industry Division, has been appointed Officer-in-Charge of the C.S.I.R.O. W.A. Regional Laboratory, and *Mr. M. J. Mulcahy* of Soils Division is the Deputy Officer-in-Charge.

Mr. R. H. Brown of Westralian Farmer's Co-operative Limited was recently appointed manager of the Jutes, Seeds and Fertiliser's Department of that firm.

Mr. D. R. Grant-Frost of the Shell Chemical Co., has been transferred from W.A. to Tasmania.

Mr. R. S. Watt formerly a Research Officer in the Department of Agriculture has recently taken up an appointment as Field Extension officer in W.A. for Potash (Aust.) Ltd.

Mr. J. F. S. Browne an Animal Husbandry officer with the New Guinea Dept. of Agriculture, Stock and Fisheries, is now stationed at Nondugl. His work is associated with the nutritional status of animals and pastures in New Guinea.

Mr. C. J. Asher a Rice Agronomist with the New Guinea Dept. of Agriculture, Stock and Fisheries is now stationed at Epoy.

Mr. C. W. Langley, formerly of the New South Wales Dept. of Agriculture has accepted a position as Technical Adviser with Westralian Farmer's Co-operative Limited.

Mr. B. Argyle of the Wheat and Sheep Division of the Department of Agriculture was recently appointed Agricultural Adviser for the Eastern Wheatbelt districts, stationed at Merredin.

Mr. F. Melville a senior adviser in the Horticultural Division of the Department of Agriculture left for England in February last and will be abroad for about eight months. During this time Mr. Melville will act as Assistant Fruit Officer in London, attached to the Department of Primary Industry and will make various horticultural investigations in the United Kingdom, Holland and the United States of America.

Mr. G. R. W. Meadly, the Officer in Charge of the Seed Certification and Weed Control Section of the Department of Agriculture recently left for an overseas trip as the Australian delegate to this year's meeting of the International Seed Testing Association. This Association with delegates from practically all the agricultural countries meets once every three years. The 1959 meeting is to be held in Oslo during July.

While overseas, Mr. Meadly will also investigate varietal registration and certification procedure in several of the important seed producing countries.

During visits to various institutions he proposes to discuss weed control methods, with particular attention to the use of growth regulating herbicides. Mr. Meadly plans to return to Australia by way of the U.S.A. where he will make investigations similar to those in the European countries.

Mr. T. E. McDowell, an adviser in the Wheat and Sheep Division at the Narrogin office of the Department of Agriculture and Mr. R. A. Bettenay, an adviser in the Dairying Division at the Busselton office of the Department recently attended a meeting of extension officers. Visits were made to Canberra and a number of centres in New South Wales and Victoria. Country officers from all States travelled with officers of the C.S.I.R.O. Liaison Section who arranged the programme and discussion to enable them to ascertain the type of reports and other material that would be of most use to agricultural extension workers.

Branch Notes

Australian Capital Territory

In March, the Branch Annual Meeting elected the following office bearers:
President and Delegate: *Dr. R. D. Brock.*
Vice-President: *Mr. W. M. Willoughby.*
Hon. Secretary: *Mr. G. W. Arnold.*
Hon. Asst. Secretary: *Dr. J. McWilliam.*
Hon. Treasurer: *Mr. F. H. Bollman.*
Hon. Sub-Editor: *Mr. A. F. Gurnett-Smith.*
Committee Members: *Dr. E. Phillis; Mr. W. D. Hardy; Dr. D. S. McIntyre.*

The first meeting of the winter lecture series was held in April when *Mr. J. Kinghorn* spoke on the development and current functions of the National Agricultural Advisory Service in England and Wales. *Mr. Kinghorn* is Agricultural Adviser to the U.K. High Commissioner.

The series of meetings being planned for this year will not centre around a theme similar to that used last year. The Committee has agreed that topics for meeting will be of a more specialised nature. However it is planned to hold one public meeting and to invite a nationally known speaker.

Professor T. A. Willis, Professor of Mechanical Engineering, University of N.S.W., addressed a meeting in April on "The Effect of Tillage Method on Wheat Yield".

Two social functions were held during the last quarter. In April the Institute in conjunction with S.U.A.G.A. held a welcome to the new graduates in the form of a buffet dinner at Manning House. There were 29 new Bachelors of Science in Agriculture and 13 Bachelors of Agriculture. A buffet dinner was also held in May at the Hotel Australia in honour of *Dr. R. J. Noble,* Under Secretary and Director of the N.S.W. Department of Agriculture; Dr. Noble retired in May.

The Williams report, through activity of a branch sub-committee, received publicity in N.S.W. through the press, radio, and T.V.; a leading article in the Sydney Morning Herald stimulated a number of letters to the Editor, and Professor McMillan, Dean of the Faculty of Agriculture was guest on the A.B.C. T.V. programme "Face the People".

Professor Campbell has resigned as Institute representative to the Natural Sciences Committee of UNESCO and *Professor N. H. White* has been elected to take his place.

New South Wales

At the Annual General Meeting held in February the committee members were elected for 1959. *Mr. A. J. McIntyre* was elected President.

The Presidential Address, delivered by *Mr. J. D. McFarlane,* was entitled "What Lies Ahead for the Young Graduate".

Northern New South Wales Sub-Branch

The Northern Sub-Branch held its annual general meeting on 3rd April. *Dr. R. Robertson-Cunninghame* of Deepwater was elected Chairman for 1959

and *Dr. R. F. Passey* of the New England University is deputy chairman. Committee members are *Professor R. Roe* (C.S.I.R.O., Armidale), *Mr. E. J. Waring* (University), *Mr. T. J. Croft* (Guyra), and *Mr. M. H. Walker* (Glen Innes).

Professor N. C. W. Beadle, Professor of Botany at the New England University addressed the meeting on his research work in the Fowler's Gap area, 90 miles north of Broken Hill.

Victoria

The Annual General Meeting was held on April 17 at the School of Agriculture, University of Melbourne.

The following office-bearers were elected for 1959-60.

President—*Mr. R. E. Loder.*

Vice-President—*Mr. H. R. Dickinson.*

Immediate Past President—*Mr. W. B. C. Mackie.*

Hon. Secretary—*Mr. G. W. Douglas.*

Hon. Treasurer—*Mr. M. Hawson.*

Committee Members—*Mr. R. S. Hayer; Mr. T. S. Bellair; Mr. W. P. Durk; Mr. W. R. Dickson;*

Hon. Recorder—*Mr. B. Sellars.*

Hon. State Sub-Editor—*Mr. R. R. Hedding.*

Professor of Agriculture (ex-officio)—*Prof. H. C. Forster.*

The retiring President Mr. Mackie, delivered an address entitled "Fertilisers and Farmers".

The Annual report presented at the above meeting showed that there were 473 members in the branch as at December 31, 1958. This was an increase of 44 over the previous year's figure.

During the year the Branch was honoured by the election of two of its members, Sir Ian Clunies-Ross and Sir Samuel Wadham, as Fellows of the A.I.A.S.

The continued activities of the Branch's eleven sub-committees have done much to maintain branch activity and achieve a high level of member-activity.

On February 26 *Dr. H. P. Schapper* addressed members on the subject of "Farm Management Clubs for Australia". With the increasing interest being shown in this form of activity, Dr. Schapper's remarks, based largely on his personal experience with Management Clubs was of very great interest.

Queensland

The 24th Annual General Meeting of the Branch was held at the Department of Agriculture, University of Queensland on April 1.

The officers elected for 1959 were as follows:—

President—*Mr. O. W. Sturgess,* Pathology Section, Bureau of Sugar Experiment Stations.

Vice Presidents—*Mr. F. Chippendale,* Plant Nutrition Section, Department of Agriculture and Stock.

Dr. D. O. Norris, Plant and Soils Laboratory, C.S.I.R.O.

Hon. Secretary—*Mr. A. Hegarty,* Agriculture Branch, Department of Agriculture and Stock.

Hon. Asst. Secretary—*Mr. A. Johnson,* Plant Nutrition Section, Department of Agriculture and Stock.

Hon. Treasurer—*Miss D. Nunn,* Sheep and Wool Branch, Department of Agriculture and Stock.

State Sub-Editor—*Dr. B. R. Champ,* Entomology Section, Department of Agriculture and Stock.

Committee Members—*Dr. E. M. Hutton,* Plant and Soils Laboratory, C.S.I.R.O.; *Mr. S. Marriott,* Agrostology Branch, Department of Agriculture and Stock; *Dr. G. L. Wilson,* Botany Department, University of Queensland.

The retiring Branch President, *Dr. D. O. Norris* gave for his Presidential Address a very informative account of "Legume bacteriology in the tropics."

A field day was held at the C.S.I.R.O. Pasture Research Station, Samford, on Saturday, May 2. Fifty visitors, members and their families, were taken on a tour of the farm, during which they saw some of the experimental work being carried out by the staff of the Plant and Soils Laboratory, and afterwards the party gathered for a picnic lunch.

South Australia

The Annual General Meeting was held at the Waite Institute on February 27, when the following members were elected office bearers in the 1959 Committee:—

President—*Mr. P. C. Angove*

Vice-President—*Dr. G. M. E. Mayo*

President-Elect—*Mr. J. C. M. Fornachon*

Hon. Secretary—*Mr. E. W. Boehm*

Hon. Assistant Secretary—*Mr. G. R. Edwards*

Hon. Treasurer—*Mr. P. Judd*

Hon. Sub. Editor of Journal—*Dr. P. F. Brownell*

Committee Members—*Mr. K. P. Barley, Mr. T. C. Miller, Mr. R. M. Carrail.*

Hon. Auditors—*Dr. A. Rovira, Mr. M. B. Spurling.*

The implications of the D. B. Williams Report were discussed at a meeting with the Premier by *Mr. W. F. Nankivell, Dr. J. Melville* and *Dr. G. M. E. Mayo.*

Consideration is being given to the organisation of a school for representation of agricultural industries during 1959. *Mr. T. C. Miller* will convene a sub-committee for this purpose.

At the Annual General Meeting, the Branch Prize for 1959 for the most distinguished student completing the course in Agricultural Science for the year was presented to *Mr. J. V. Jacobsen.* He was recently appointed as a Research Officer in the Horticultural Branch of the Department of Agriculture.

A stimulating address on "The Evolution of Our Institute" was given by our retiring President, *Dr. G. M. E. Mayo,* in which he clearly described the organisation and development of the Institute.

Mr. R. H. Kuchel, Senior Oenologist and Biologist at Roseworthy Agricultural College, spoke on "The People and Agriculture of Cyprus" at the Branch meeting held on April 17.

Tasmania

The Immediate Past President, Mr. David Berry, delivered his Presidential Address in Hobart on April 10, and in Launceston on April 30, Mr. Berry spoke on "Developments in the New Zealand Fertiliser Industry" illustrating his talk with colour slides showing the facilities for bulk handling and aerial application of superphosphate.

Western Australia

March Meeting. The first meeting for 1959 was held on March 20, when the guest speaker was *Mr. R. J. Moir,* Senior Lecturer in Agriculture at the Institute of Agriculture, University of W.A., the subject of the address being "Some Animal Research in the U.S.A., U.K., and in Africa." Mr. Moir recently spent 12 months overseas, mostly at Utah State College, Logan, Utah, and during his talk, described some of the animal work he was able to see in progress and also gave an account of his own studies whilst abroad.

Annual General Meeting.

The Annual General Meeting was this year separated from the Annual Dinner which will be held as a separate social function during the winter months. The Annual Meeting was held on April 17, when the following committee was elected:—

President—*Mr. R. H. Brown.*

Vice President—*Mr. N. J. Halse.*

Hon. Secretary—*Mr. H. E. Fels.*

Hon. Asst. Secretary—*Mr. D. B. Purser.*

Hon. Treasurer—*Mr. T. C. Stoneman.*

Journal Sub-Editor—

Committee Members—*Mr. G. H. Burvell, Mr. F. J. Roberts, Dr. L. C. Snook, Dr. C. H. Parker,*

Past President—*Mr. M. M. Wallace.*

The Executive officer, *Mr. J. A. Roberts* was present, gave a short address and answered numerous questions.

At the conclusion of the formal business session drinks were served, visitors welcomed and the retiring president *Mr. M. M. Wallace* delivered the Presidential Address entitled "Ecology as the Basis of Pest Control".

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In the "Monkey" Grubber way clearing work is done expeditiously and without great outlay, leaving land ready for mechanical tilling. The machine delivers 260 times the power applied to the handle. It is portable and fitted with an automatic lowering gear, second speed, rope shortener, snatch block, etc. Cable equipment is generous and comprises 180 feet in four lengths each fitted with special labour and time-saving couplings. Takes an acre and a half from an anchor.

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VACANCIES

PLANT PATHOLOGIST GRADE I (Microbiologist)—£1,301-1,706 p.a. (See also under "Salary").

Qualifications: University degree with specialisation in pathology, bacteriology and mycology.

Duties: Mainly microbiological, including research with symbiotic bacteria and/or microbiological compound in cocoa fermentation and tropical crop spoilage.

Location: Keravat, via Rabaul.

SOILS SURVEY OFFICER GRADE I (Two positions)—£1,346-1,706 p.a. (see also under "Salary").

Qualifications: Degree in Agricultural Science, preferably with specialisation in soil science.

Duties: Soil surveys, prepare maps and co-relate data.

AGRONOMIST GRADE I—£1,346-1,706 p.a. (See also under "Salary").

Qualifications: Degree in Agricultural Science, preferably with specialisation in agronomy.

Duties: Experimental work in agronomy.

ASSISTANT AGRICULTURAL OFFICER (Several positions)—£761-1,346 p.a. (For special commencing rates see under "Salary").

Qualifications: Diploma approved agricultural college or equivalent.

Duties: Extension duties, supervise special projects, technical duties for specialist divisions.

GENERAL INFORMATION

Salary: Rates quoted are actual for unmarried appointees and include allowances and adjustments. Married officers receive a further £125 p.a. Additional Territorial allowance of £25 p.a. after five years' service and a further £25 p.a. after seven years' service is also payable. Commencing rates for Assistant Agricultural Officers are:

	Unmarried p.a.	Married p.a.
At 18 years	£761	
At 19 years	£836	£1,108
At 20 years	£937	
At 21 years	£1,008	£1,111
At 22 years	£1,031	£1,156
At 23 years and over	£1,076	£1,201

Appointees to all positions will receive commencing salary within range according to qualifications and experience.

Eligibility: Male British subjects under 45 years. (Applicants for Assistant Agricultural Officer must be at least 18 years.)

Appointment: Permanent on probation.

Location: Appointees are required to serve anywhere in Territory. Where location is stated it refers to headquarters or initial posting only.

Accommodation: Single quarters available; married accommodation unlikely to be available under 18 months from date of appointment.

Separation Allowance: Payable at discretion of Territory Administration; designed to compensate for added expense of married appointees obliged to maintain family outside Territory.

Leave: Three months after each twenty-one months in the Territory. Additional three months' leave after each six years' service and six months' furlough after twenty years' service.

Further Information: An information handbook on the Territory Public Service is available from Department of Territories, Canberra or Sydney, or from any Commonwealth Public Service Inspector, Commonwealth Employment Office or official country Post Office. Other enquiries to Department of Territories, Canberra (telephone U 0411, Ext. 29A).

Applications: Submit on prescribed form available from offices mentioned under "Further Information"

TO The Secretary, Department of Territories, Canberra, A.C.T.
by 31 July, 1959.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF ANIMAL HEALTH AND PRODUCCTION

SHEEP BIOLOGY LABORATORY

APPOINTMENT OF ANIMAL PHYSIOLOGIST

Applications are invited for appointment to a position of Animal Physiologist with the Organization's Division of Animal Health and Production, located at the Sheep Biology Laboratory, Prospect, New South Wales.

A major project at the Laboratory is the study of all phases of reproduction. It is now desired to appoint a Research Officer whose primary interests would be in the physiology of the ewe—the mechanisms involved in ovulation and oestrus, mating behaviour, and fertility and fecundity. Work is required both in the laboratory and in the field, and ecological aspects will be given special attention.

Applicants should possess a University Honours degree in Science or Agricultural Science, or a degree in Veterinary Science, with some years of post-graduate research, not necessarily in this specialised subject. An appointee in the Research Officer grade would initially work under the supervision of a senior officer.

Dependent upon qualifications and experience, commencing salary will be determined within the salary ranges of Research Officer, £1326-£1951 p.a. (actual), or Senior Research Officer, £2061-£2336 p.a. (actual). Salary for a female appointee would be £170 p.a. less than the corresponding male rates.

The appointment will be conditional upon a satisfactory medical examination and an initial probationary period of up to twelve months may also be specified. Confirmation of appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges.

Applications quoting reference number 205/173 and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the Officer-in-Charge, C.S.I.R.O. Sheep Biology Laboratory, P.O. Box 144, Parramatta, New South Wales, by **17th July, 1959.**

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